
LELAND·STANFORD·JVNIOR·VNIVERSITY

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY.

EDITED BY

A COMMITTEE OF THE COUNCIL.

VOL. XXII.—1896.

LONDON:
EDWARD STANFORD, 26 & 27 COCKSPUR STREET,
CHARING CROSS, S.W.
1896.

TABLE OF CONTENTS

LIST OF PLATES.

ERRATA.

Page	193,	line	17, *for*	1 mm.	*read* 1 $\mu\mu$.
,,	,,	,,	23	,,	,,
,,	,,	,,	30	,,	,,
,,	,,	,,	41	,,	,,
,,	195	,,	9	,,	,,

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY

VOL. XXII.] JANUARY 1896 [No. 97.

ON THE ORIGIN OF THE COLD WEATHER STORMS OF THE YEAR 1893 IN INDIA, AND THE CHARACTER OF THE AIR MOVEMENT ON THE INDIAN SEAS AND THE EQUATORIAL BELT, MORE ESPECIALLY DURING THE SOUTH-WEST MONSOON PERIOD (AS SHOWN BY THE DATA OF THE INDIAN MONSOON AREA CHARTS FOR THE YEAR 1893).

By JOHN ELIOT, M.A., F.R.S.,
Meteorological Reporter to the Government of India.

[Read November 19, 1895.]

THE Government of India, in the year 1892, sanctioned the publication for two years (viz. 1893 and 1894) of Daily Charts, giving the chief features of the Meteorology of the Indian Monsoon area. I propose in the present paper to discuss some of the points on which these Charts, for the first year of their publication, have shed light.

Indian Monsoon Area.

The Indian Monsoon area includes that portion of Southern Asia and the adjacent seas in which the year is primarily divided into two seasons of nearly equal period and of opposite meteorological conditions, one being characterised by the prevalence of dry land winds, and the other by the prevalence of sea winds of great volume and intensity. These seasons are known as the North-east Monsoon and the South-west Monsoon, so called from the prevailing winds in the open sea areas of the Bay of Bengal and Arabian Sea.

The general direction of the lower air movement over India during the North-east or dry Monsoon is from the interior of the land areas towards the ocean, but its local direction is mainly determined by the river valleys. This air movement is very feeble over the whole of North-Western India, and its rate, during the greater part of the period, *i.e.* from

December to February, does not average more than 2 or 3 miles per hour. Various phenomena suggest, if they do not establish, that this current over India is comparatively shallow. Little or nothing is actually known of the vertical succession of currents below the cirrus region. The daily observations of the cirrus show that there is a constant strong drift in the upper atmosphere from about west-south-west or west to east-north-east or east. The lower air-current of the North-east Monsoon has its origin as a horizontal movement in Upper India. It is undoubtedly fed, to some extent, by air-drift down the passes or valleys running transversely through the mountains bounding the north-west frontier of India. It is not, however, the continuation of a horizontal current advancing from Afghanistan or Baluchistan, or across the Himalayas from Thibet. One of the more remarkable features of the meteorology of the frontier districts (more especially the Kachhi Desert in Sind) is the stillness of the air on ordinary fine days in the cold weather. This is, of course, accounted for by the preceding statement of the northern limit of the North-east winds as a lower horizontal air movement.

During the months of March, April, and May the air movement in the interior is unchanged in general direction, but is intensified by the thermal conditions; whilst in the coast districts sea and land winds of greater or less intensity, due to the same conditions, prevail. The combination of these air movements gives rise to a complex system of winds, which are shown more or less fully in the published Daily Weather Charts of the period.

The South-west Monsoon obtains from June to November, during which time strong and steady oceanic currents prevail and extend over the whole of India, giving high humidity, moderately high temperature with small diurnal range, and frequent and heavy rain.

One of the objects for which the preparation of these charts was undertaken was to ascertain the origin of the cyclonic storms that pass over Northern India during the cold weather, and which are the chief source of the snowfall of the Western and Central Himalayas.

It may be presumed by way of explanation that cyclonic storms are of frequent occurrence in each of the two seasons, viz. the North-east Monsoon and the South-west Monsoon. The storms of the two seasons, however, differ in many important respects, and to such an extent that they may be regarded as belonging to two different classes or types of cyclonic disturbances. The storms of the South-west Monsoon originate almost invariably over a sea surface, and travel in very variable directions, ranging between west and north-east, and with very varying velocity, and occasionally develop into intense and furious hurricanes. The cyclonic storms of the North-east Monsoon almost invariably originate over the plateau of Persia or in Baluchistan, or North-Western India. They travel in a nearly constant direction (averaging between east and east-south-east), and with a moderately high and nearly uniform velocity, ranging between 15 and 20 miles per hour. Finally, they are, as storms, feeble, or, in other words, they are never near the sea-level accompanied by violent winds or with cyclonic downpours of rain. The plateau-formed storms of the cold weather are the chief instruments of the distribution of the moderate rainfall essential for the cold weather wheat and other crops of Northern India, and are the chief sources of the snowfall of

the Western Himalayas; and hence their economic importance and the necessity for investigating their origin, preparatory to commencing the work of issuing seasonal forecasts for this period, as well as for the South-west Monsoon period.

Cold Weather Storms, January and February 1893.

The following gives a brief sketch of the origin of the cold weather storms of the months of January and February 1893, and of the meteorological conditions obtaining in Eastern and Southern Europe at the time of their inception, and also a statement of the chief conclusions derived from their examination.

Seven fairly well-defined cold weather storms passed across Northern India during the cold weather of 1892-93. The first originated probably in the Persian area in the last week of December. Its later stages are hence only shown in the series of charts for 1893.

The following is a brief statement of the chief circumstances of the origin and march of the six cold weather storms shown in these charts for the months of January and February 1893:—

(1) *Cold Weather Disturbance of January* 12*th*–17*th*.—A depression formed in the Mediterranean Sea on the 1st and 2nd. It advanced slowly from the Gulf of Lyons south-eastwards, but filled up partially on the 6th and 7th. A cyclonic storm crossed West and Central Europe on the 8th, 9th, and 10th, and passed into Central Russia on the 11th and 12th. Fine weather prevailed in the Persian area during the first week of January. Pressure gave way slightly on the 8th and 9th, but increased slightly on the 10th over the Persian and Indian areas. The pressure changes were small in the Persian area on the 12th and 13th, but were large in North-Western India and Baluchistan. Weather was cloudy and disturbed in Persia and the Persian Gulf on the 10th and 11th. A depression formed during the next 24 hours in Baluchistan and Upper India, which drifted east-south-eastwards across Northern India during the next four days. The central depression was in Baluchistan on the morning of the 12th, Sind on the 13th, Central Rajputana on the 14th, Bagelkhand and the south-eastern districts of the North-Western Provinces on the 15th, Bihar on the 16th, and Bengal on the 17th. It hence advanced at an average rate of about 400 miles per diem.

A second but very feeble disturbance affected Upper India on the 16th and 17th. It almost certainly originated as a very shallow depression in Baluchistan during a period of slightly disturbed weather in the whole Persian area, and advanced in the rear of the preceding disturbance, and its chief effect was to prolong the rainy weather in Upper India initiated by the previous disturbance. It was of very slight intensity throughout, and is hence not reckoned as a cyclonic storm. The double disturbance gave an unusually heavy and prolonged burst of rain to the whole of North-Western India, and heavy snowfall in the Western Himalayas.

(2) *Storm of January* 22*nd*–26*th*.—A low pressure area lay over the Gulf of Lyons on the 15th. It shifted slowly in a south-easterly direction, and covered Italy and Sicily on the 19th, and filled up during the next 48 hours in the eastern half of the Mediterranean Sea. It advanced at an average rate of about 180 miles per diem from 6 p.m. of the 15th to 6 p.m. of the 18th. During the whole of this period a well-marked high pressure area lay over Russia, and anticyclonic conditions extended from that area over the whole of Southern Europe and the Mediterranean on the 19th and 20th.

Weather was fine and clear in the Persian area and Northern India on the

20th and 21st. Pressure gave way in Persia on the 21st, and increased in Northern India. It decreased over the whole of Persia, Baluchistan, and Northern India during the next 24 hours, the fall being greatest in Baluchistan; and on the morning of the 23rd an area of considerable deficiency of pressure lay over Sind, Baluchistan, and East Persia. The barometric observations at Baghdad and Bushire indicate clearly that the disturbance was formed in Baluchistan and East Persia on the 22nd, and was not transmitted eastwards across Turkey from South-eastern Europe.

The storm consisted of a well-marked primary depression, which advanced nearly due eastwards. The central depression was in about long. $68\frac{1}{2}°$ E. at 8 a.m. on the 23rd, in long. $74\frac{1}{2}°$ E. on the 24th, in long. $81\frac{1}{2}°$ E. on the 25th, and in long. $88\frac{1}{2}°$ E. on the 26th. Its average rate of motion was hence about 400 miles per diem, or 17 miles an hour. A feeble secondary depression formed in the Punjab on the 24th and filled up during the next 24 hours. This double storm gave moderate to heavy rain over the whole of Northern India, and heavy snow in the Western Himalayas and Afghan mountains.

(3) *Cold Weather Storm of January 27th–30th.*—Anticyclonic conditions prevailed in Eastern and Southern Europe (pressure ranging between 30·0 in. and 30·8 in.) from the 24th to the 28th. A depression lay over South Russia on the 23rd, and advanced north-eastwards on the 24th. Pressure was steady in Asiatic Turkey and Persia on the 22nd and 23rd, and increased on the 24th. On the 25th and 26th it fell slightly at Baghdad and Bushire, and rapidly in Baluchistan and East Persia; and on the morning of the 27th a shallow depression lay over that area.

The evidence hence appears to be conclusive that it was formed in Baluchistan and East Persia. It advanced rapidly eastwards, and was central in long. 64° E. on the morning of the 27th, in long. 74° E. on the 28th, and in long. 84° E. on the 29th. Its average rate of motion was 600 miles per diem from the 27th to the 29th. A deepish secondary depression formed rapidly in the Punjab on the 28th, and filled up equally rapidly during the next 24 hours. The double disturbance gave slight to moderate rain over Sind and the Punjab, and light showers in the Gangetic plain and heavy snow in the Western Himalayas.

(4) *Storm of February 4th–8th.*—Anticyclonic conditions held steadily in Southern and Eastern Europe from January 24th until the end of February. Pressure was abnormally high in the Black Sea on the 3rd and 4th, when the present storm was generated. Weather was fine and clear, and pressure increasing at Baghdad and in Persia on the 31st. No change occurred at Baghdad during the next 48 hours. Pressure gave way briskly in Central Persia on February 1st and 2nd, and a well-marked disturbance was shown on the morning of the 3rd in Eastern Persia and the Gulf of Oman, where winds of force 5 to 7 were experienced by several vessels during that day.

The whole of the observations indicate that the depression formed on the 1st and 2nd in Central Persia. The central depression was in long. 60° E. at 8 a.m. on the 4th, in long. 64° or 65° E. on the 5th, in long 74° E. on the 6th, in long. 84° E. on the 7th, and in long. 93° or 94° E. on the 8th. It hence advanced from the 5th to the 8th at the rate of about 600 miles per diem, or 25 miles an hour. It gave rise to a very feeble secondary depression in the Punjab on the 6th. The mean strength of winds in the Gulf of Oman and the north of the Arabian Sea in January and February is 2·0, and ranges between 1 and 3. Winds of force 6 to 9 were reported by several vessels on the 7th, with "blinding rain" in the Gulf of Oman and off the Mekran coast, and the storm was hence of moderate severity and intensity in that area.

(5) *Storm of February 11th–14th.*—Marked anticyclonic conditions continued, as already stated, in Southern and Eastern Europe from January 24th until the last week of February. Pressure increased on the 8th over the whole

of Persia and India. It fell in Persia on the 9th and continued to rise in India. It decreased rapidly in Persia during the next 24 hours and began to fall in India, and on the morning of the 11th a shallow depression lay over South-east Persia and the Gulf of Oman. The depression was stationary in South-east Persia during the next 24 hours, a strong confirmation of the inference, from pressure and other data, that it formed in that area. It advanced from about long. 60° E. on the 12th to long. 72° E. on the 13th, and to long 84° E. on the 14th ; and hence at an average rate of nearly 30 miles an hour, and even more rapidly than the preceding two depressions. It also marched along a more southerly track than the preceding storm. It was throughout a feeble disturbance, but gave cloudy weather and light to moderate rain showers for a brief period in Northern India.

(6) *Cold Weather Storm of February 21st–25th.*—High pressure conditions prevailed in South and South-east Europe prior to and during the generation of this depression. It formed in the Persian area on the 19th during a short period of uniform pressure. Pressure gave way briskly on the 18th and 19th in West and Central Persia, and on the morning of the 20th an area of deficient and low pressure lay over that area. It advanced eastwards, intensifying during the next 24 hours, and the centre was in about long. 63° E. at 8 a.m. of the 21st. It passed into North-Western India on the 22nd, giving rise to a slight secondary depression in the Punjab. This depression filled up before the morning of the 23rd, but the primary depression continued to pass eastwards as a very feeble disturbance. The centre was probably in about long. 72° or 73° E. at 8 a.m. on the 22nd, in about long. 80° E. on the 23rd, and in long. 88° E. on the 24th. It hence advanced at an average rate of about 500 miles per diem from the 21st to the 24th.

The precipitation accompanying these storms is generally small in amount in the plains of Northern India, and usually decreases in amount eastwards down the Gangetic plain and southwards from the Himalayas. The precipitation (which occurs chiefly as snow) is, on the other hand, large in amount in the Western Himalayas, and increases rapidly with elevation on the southern face of that mountain range.

The character and distribution of the precipitation during the storms of January and February 1893 is given below:—

TABLE I.—Rainfall in Plains of Northern India.

1893.	Punjab.	Rajputana and Central India (W).	N.W. Province.	Central India.	Bihar.	Bengal.
	in.	in.	in.	in.	in.	in.
Jan. 1–3	0·24	0·17	0·17	0·21	...	...
„ 12–17	0·45	0·01	0·20	0·03	0·04	0·01
„ 22–28	1·30	0·45	0·58	0·13	0·47	0·41
Feb. 4–8	0·45	0·08	0·33	0·03	0·15	0·39
„ 11–14	0·85	0·06	0·37	0·02	0·44	0·72
„ 21–25	1·17	0·47	1·14	0·37	1·13	1·29
Total .	4·46	1·24	2·79	0·79	2·23	2·82

TABLE II.—SNOWFALL IN THE WESTERN HIMALAYAS.

1893.	Murree, 6344 ft.	Chamba State, Forest Stations.				Gurhwal and Kumaon, 8000 to 12,000 ft.
		Tisa, 5000 ft.	Bhandela, 5500 ft.	Thanela.	Dalhousie.	
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. ft.
January	12 1	6 3	12 3	11 8	15 4	16 to 30
February	13 10	*	*	*	*	10 to 20
Total	25 11					26 to 50

* The snowfall measurements of these stations for February have not been received.

Except in Gurhwal and Kumaon the amounts given above were obtained from exact measurements. The fall on the Gurhwal passes was estimated by the subordinate native officials of that district. The estimate, however, agrees closely with the actual measurements made at Murree and in the Chamba State.

It is almost certain that the snowfall in the Himalayas to the north of Kashmir, Punjab and North-West Provinces is received almost entirely during the North-east Monsoon, and that little falls during the South-west Monsoon, and the preceding estimate of the fall during the two months of January and February 1893 shows that the winter supply is almost certainly sufficient for the summer and autumn melting.

The foregoing has given a brief account of the more important cold weather storms which affected Northern India in January and February 1893. One only of these storms was formed shortly after a storm had passed eastwards from the Central to the East Mediterranean and Black Seas, but it does not appear to have been the continuation of that storm. The remaining storms were all initiated in the Persian area during the prevalence of high pressure conditions in South and South-east Europe.

The cold weather storms of 1893 were, with perhaps one exception, formed in the plateau of Iran during the prevalence of strongly marked and persistent anticyclonic conditions to the north and west. It is probable that these represent the combination of conditions most favourable to their formation.

The storms advanced in easterly directions at an average rate of about 500 miles per diem, or slightly greater than the mean rate deduced from the imperfect information utilised in my paper on "Cold Weather Storms in India, 1876-91."[1]

It is hence almost certain that, with perhaps very rare exceptions, the cold weather storms of the Indian Monsoon area are not the continuation of European storms, and that the large majority of the more important depressions and storms of the Indian area in the months of December, January, and February are generated in the plateau area between the Euphrates and Indus valleys. Whether their formation is dependent upon the conditions to the north and west (*i.e.* in Russia and Turkestan) can as yet only be surmised; but it appears to be most probable that

[1] *Indian Meteorological Memoirs*, vol iv. p. 856.

the prevalence of anticyclonic conditions in Russia would be undoubtedly favourable, and this is borne out by the experience of 1893.

The continuation of the work of observation in Persia will, it may reasonably be expected, throw much light on the conditions and circumstances of the generation of these plateau-formed storms in Persia, which form in many respects a striking contrast to the cyclonic storms of the South-west Monsoon in India.

The South-west Monsoon.

The *Indian Monsoon Area Charts* for 1893 throw a considerable amount of light on the character of the air movement of the South-west Monsoon in the Indian Seas, and on the changes which accompany the advance or establishment, and the retreat of the oceanic current from the Indian Monsoon land area. As to the phenomena and the causes of this current, there is a considerable diversity of opinion amongst meteorologists, so far as can be judged from the current literature. The phenomena are, to any one who has lived for some years in the interior of Northern or Central India, simple and broadly marked. Before the setting in of the South-west Monsoon, intensely dry hot weather prevails, and strong land winds laden with dust blow down the large river valleys of the Ganges, Brahmaputra, and Indus, towards the sea. This weather lasts for two or three months (*i.e.* March to June), with increasing intensity until the month of June, when finally a series of thunderstorms burst over the country and initiate a complete change of winds and weather. The change—almost certainly the most rapid and complete seasonal change to be observed in any country of the world—is frequently effected in the space of a few days over nearly the whole of the large area including Northern and Central India. This sudden change, termed very significantly "the burst of the Monsoon," is too frequently overlooked in the explanations that are given of the South-west Monsoon. Before deducing from the charts for 1893 some of the facts which appear to throw light on the phenomena of the advance and withdrawal of the South-west Monsoon proper from India, I give extracts from various meteorological works, which state the views generally held at the present time, of the causes which determine this massive change.

The following represents Ferrel's views, as given in his last work, *A Popular Treatise of the Winds*:—

Monsoon winds, like land and sea breezes, are due to periodic alternations of the relative temperature conditions or disturbances of the normal conditions between sea and land. They are atmospheric disturbances arising from differences of temperature between continents and the surrounding ocean, or between any region of the earth's surface abnormally heated or cooled and the surrounding parts. The strength of the Monsoon winds depends much upon the nature of the surface of the continent. They are most vigorous in countries and in oceans adjacent to high mountain ranges. The Monsoon winds in India owe a portion of their strength to the presence of the vast Himalayan mountains and the Central Asian table-land. As the sun approaches in its annual march the northern tropic, the air of the Himalayan southern slope, the desert of Gobi and the sun-burnt places of Central Asia are warmed to a temperature much above that of the adjacent and surrounding area at a distance on the same level, thus occasioning a powerful centripetal and ascensional tendency in which the

air is drawn in towards the centre of warmth and rarefaction from all sides, but especially from the equatorial side. The indraught when once established is in large part maintained by the energy released during the condensation of the rainfall of the period.

The wind data that have been collected establish that during the South-west Monsoon the South-east Trade Winds gradually change in advancing across the equator to South-west winds to the north of the equator, the observed directions being mostly south-east to the south of the equator and south-west to the north of it, and there is no calm belt during that period at or near the equator.

Scott in his *Elementary Meteorology* says that "the Monsoons of Southern Asia exhibit the dependence of air motion on temperature on the extensive scale." He also states that "the explanation advanced first by Dove that the South-west Monsoon is produced by the great rarefaction of the atmosphere over Central Asia is not sufficient to explain the phenomena, more especially the non-advance of Monsoon winds across the Himalayas into Thibet."

Abercromby in his *Weather* describes briefly in the following terms the changes initiating the South-west Monsoon :—

In the month of February we find a very shallow stationary depression—not a cyclone—over Lower Bengal, a belt of high pressure stretching across the Bay of Bengal from Madras to Rangoon, and a general diminution of pressure from that belt to the equator. From this we might reasonably expect what we find—light South-west wind over Lower Bengal, variable breezes over Madras, and a light North-east Monsoon across Ceylon; but it is not so obvious why the South-west wind should be so fine and dry as it is. The low pressure over Bengal gets gradually more pronounced, and spreads with its accompanying South-west winds slowly southwards, till Ceylon is embraced within its sphere. These conditions are most pronounced towards the end of May, and we get the dry, nearly cloudless, hot season of India and Ceylon with a light South-west wind. Then the sky begins to cloud over, and suddenly rain bursts in a series of terrific thunderstorms, and the bad, wet weather continues for two or three months. The rain begins in Ceylon, and then works slowly up the west coasts of India and Burma—omitting Madras—till Calcutta and Lower Bengal are reached, three or four weeks later than Colombo. Then we are met by the strange fact that this, the most striking weather-change in the whole year, is associated by no change in the shape of the isobars. When the Monsoon is fairly established, we can, no doubt, see certain slight fluctuations in the shape and intensity of the isobars which accompany what is called "a break in the rains," and sometimes exceptionally heavy rain falls during the passage of a small cyclone from the Bay of Bengal up country; but we cannot find any change in the isobars to account for the sudden change of weather which is called in common parlance "the burst of the Monsoon." The only rational suggestion which has been made to account for this burst of rain would look to a sudden inrush of damp air from the region of the Doldrums as the source of the change in weather, but not of the direction of the wind, or of the shape of the isobars; for the burst is apparently almost coincident with the disappearance of the belt of high pressure to the south of the Bay of Bengal.

W. M. Davis in his *Elementary Meteorology* states :—

The Monsoons of India are the most famous winds of their class. Their name is derived from an Arabic word, meaning season. The belt of low pressure

that lay to the south of the equator in our winter migrates gradually northward in spring, and is finally replaced by the formation of an area of low pressure over the warm desert plains of India and Persia, even as early as May. A northward gradient then leads the South-east Trades of the South Indian Ocean across the equator, and on entering our hemisphere they swing around and blow from the South-west, thus presenting one of the most interesting phenomena in the circulation of the atmosphere. The Northern Indian Ocean and the adjacent seas are thus alternately swept over by winds of North-east and South-west directions, and on land these winds dominate the change of the seasons.

The cause of this is stated briefly in the same work as follows :—

In the summer season, Asia is the seat of unduly high temperatures, and by the aid of its numerous lofty mountains and plateaux a great depth of atmosphere is warmed abnormally. The high pressure of winter is then reversed into a low pressure, and the winds blow inward from all sides, even from the South Indian and the Arctic Oceans. Over India the general direction of this Monsoon is from the South-west, but it is turned to the South-east in the plains of the Ganges.

Finally Blanford in his *Rainfall of India* says :—

Beyond the general fact that the summer Monsoon originates over the ocean which stretches away to the south and west of India, and that its vapour-burden is the tribute collected from the evaporating surface of these warm seas, very little is at present known respecting the cradle and earlier course of this wind current. It is generally considered that it is, in part, the continuation across the equator of the South-east Trades; but there are some reasons for believing that any connection of the southern Trades with the Indian Monsoon is at least fitful and partial, and there can be little or no question that the Northern Indian Ocean presents an expanse of evaporating surface, which, supplemented by that of the Bay of Bengal, and that of India itself, is sufficient to supply all the rain that falls annually on the plains and mountains of India. Instead, then, of the Monsoon being simply a prolongation of the Trades, the case would rather seem to be that most frequently it originates in this variable but on the whole westerly and rainy current over the equator in the South-west Monsoon, which is doubtless fed by the South-east Trades, and consists of nearly saturated air; but it represents only a portion of the air poured by the Southern Trade winds into the equatorial region, the remainder ascending convectively, precisely as in the Atlantic Doldrums. Nor is the Monsoon drawn from this source alone. It is probably recruited, to a very considerable extent, from more northern latitudes, especially during fine intervals when the current is slacker, and the rainfall on the Indian mainland less copious; and it is to the varying degrees in which the two sources of supply are respectively drawn upon to furnish the indraught, that I would attribute the variations of the rainfall during the progress of the season.

Ferrel, Davis, Scott, and Abercromby agree in considering the South-west Monsoon winds as the direct continuation of the South-east Trades impelled across the equator by special temperature and pressure conditions in India or Central Asia. Blanford, on the contrary, appears to hold that there is, throughout the whole period, a belt of calms and light winds over the equator, which serves as a species of reservoir or tank into which the South-east Trade winds are absorbed, whilst from it on the north issue the South-westerly to Westerly winds of the rainy Monsoon.

Blanford's opinion is, of course, entitled to special weight from his intimate acquaintance with the phenomena and meteorology of the Monsoons in India. No clear or definite explanation is given by any of these meteorologists of the sudden change known as "the burst of the Monsoon," or of the other more prominent features. Exception might also be taken to portions of the statements of these meteorologists, which are apparently based in part at least on the examination of mean pressure and wind charts.

Winds in the Equatorial Belt, 1893.

With the view of ascertaining whether the South-west Monsoon may be properly regarded as the continuation of the South Trade winds of the Indian Ocean, impelled northwards across the equator by special conditions and actions, and thence deflected eastwards mainly, if not entirely, by rotational action of the earth (that is, by the hypothetical or fictitious force introduced to enable the motion of the air over the moving surface of the earth to be calculated on the supposition that the earth is at rest), I have tabulated the whole of the wind data for the equatorial belt given in the 1893 *India Monsoon Area Charts.*

In order to show the character and variations of the air movement in the equatorial belt as fully as the limited number of the observations will permit, the whole of the data for the year 1893 have been tabulated for six divisions of that area. The equatorial belt is taken to include the area between the 8th parallel of south latitude and the 4th parallel of north latitude, and is divided into three portions by the 4th parallel of south latitude and the equator. The meridian of 76° E. longitude divides each of these strips into an eastern and western half. These six divisions are for shortness designated as the south, middle and north sections of the western half, and of the eastern half of the belt.

The following gives a brief analysis of the mean air movement in the equatorial belt from month to month in 1893.

January 1893.

TABLE III.—Winds in the Western Half of the Equatorial Belt.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	N. 37° E.	82%	3·0
Middle . .	N. 14° E.	65	3·2
South . .	N. 17° W.	62	2·3

Winds hence shifted through an angle of 54° in advancing from the north to the south sections. They were steadiest in the north section, and least steady in the south section, where they are also weakest. They averaged 2·8 in force over the whole of the western half of the belt.

TABLE IV.—Winds in the Eastern Half of Belt.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	N. 9° E.	50%	2·4
Middle . .	N. 48° W.	36	2·4
South . .	N. 56° W.	27	3·0

Winds averaged 2·6 in this area, and were less steady than in the western half. The shift of wind in advancing southwards was larger in

the eastern than in the western half, and occurred almost entirely between lat. 4° N. and lat. 4° S., or in the southward advance of the North-east Monsoon winds across the equator.

The shift of wind was regular in the western half, and can be explained satisfactorily as a terrestrial rotational effect. In the eastern half the shift was irregular, and it is probable that the westerly shift in this case was modified by meteorological conditions and actions due to the land area of the Malayan Archipelago.

February 1893.

TABLE V.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	N. 40° E.	76%	3·6
Middle . .	N. 16° E.	74	3·6
South . .	N. 28° W.	48	2·9

Winds in February, as in January, were deflected to west in passing southwards. The deflection was almost the same in amount in advancing from the north to the middle section as in the preceding month, and slightly greater in passing from the middle to the south section. Winds were very steady and of moderate strength in the north and middle sections, but were much less steady and weaker in the south section.

TABLE VI.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	N. 18° W.	62%	2·5
Middle . .	N. 56° W.	82	2·5
South . .	N. 83° W.	63	4·1

The air movement in February over the eastern half differed more largely from that of the western half than in January. The chief feature was the large amount of westing in the winds shown in every section, but which increased in actual amount in proceeding southwards. The data when compared with the corresponding means for the western section appear to suggest an abnormal westing of the winds in each section of the area, averaging about 50°, and almost certainly due to the action of the land masses of the Malayan Archipelago, and a westerly deflection of about 60° in passing southwards, mainly, if not entirely, due to terrestrial rotational effect. Winds were slightly weaker on the average of the whole area than in January, and were considerably stronger in the southern than in the northern and middle sections.

March 1893.

TABLE VII.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	N. 51° E.	79%	2·9
Middle . .	N. 28° E.	29	3·0
South . .	N. 80° E.	7	2·0

Winds in the north and middle sections were from the same mean directions as in January and February, and of nearly the same strength.

They were as steady as hitherto in the north section, but very unsteady in the middle section (29 per cent as compared with 74 in February).

Winds were light on the average of the month in the south section and remarkably unsteady (only 7 per cent). The mean wind direction, which was N. 28° W. in February, changed to N. 80° E. in March. This change was clearly due to the northward advance of the belt of calms (or inter-Trade wind zone) into the south section during the month.

TABLE VIII.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 45° W.	34%	2·4
Middle . .	S. 57° W.	42	2·6
South . .	N. 21° W.	41	2·2

The winds were light and unsteady over the whole of the eastern half, and the mean winds were very abnormal in direction.

The large southing of the winds in the north and middle sections is very difficult to explain, and it is probable that the winds were abnormal and due to special conditions. This is confirmed by a comparison with the wind data given in the March Chart of the Bay of Bengal Mean Pressure and Wind Charts published by the Indian Meteorological Department. The large amount of westing in the winds was, however, almost certainly an effect of the neighbourhood of the land masses of Sumatra, Java, etc.

April 1893.

TABLE IX.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 68° W.	27%	2·5
Middle . .	S. 28° E.	51	3·0
South . .	S. 70° E.	89	3·6

Steady east-south-east winds of moderate intensity prevailed in the south section in April 1893. Winds were weaker and much less steady in the middle section and considerably less easterly than in the south section. This westerly deflection was evidently not a direct effect of the earth's rotation. It is probable that it represents an effect of the northward advance of the inter-Trade zone to the neighbourhood of the equator, and of the frequent occurrence of light unsteady or squally winds.

The air movement was remarkable in the northern section. Winds were light and remarkably unsteady, and on the average of the whole month from West-south-west. The angle between the mean directions of the air movement in the middle and north sections was 96°, much larger than can be explained as a terrestrial rotational effect.

The consideration of the whole of the wind data suggests that the mean position of the inter-Trade zone in April 1893 was between lat. 2° N. and lat. 2° S. The prevalence of Westerly winds immediately to the north is apparently a normal feature, as it is shown clearly in the April plate of the *Weather Charts of the Bay of Bengal*, published some years ago by the India Meteorological Department. The data indicate that the South-east Trades did not advance northwards across the whole equatorial belt during this month; and the only explanation of the air movement in

the equatorial belt at this time appears to be that the South-east Trades current was absorbed into a belt of light airs and calms over the equator, and that from this as a source an irregular drift passed out northwards (with a very large easting), determined by the conditions in the Malayan Archipelago. As will be shown later this is confirmed by the distribution of rainfall and other meteorological conditions in Southern India.

TABLE X.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	N. 56° W.	61%	1·7
Middle . .	S. 79° W.	27	2·5
South . .	S. 20° E.	45	1·7

South-east Trade winds extended over the southern section in April, but were very light and unsteady compared with the winds in the corresponding section of the western half.

Winds were very light and irregular in the central and north sections. They were also very unsteady in the middle section. The strong northerly element in the winds in the northern section was apparently a peculiar feature of the year 1893. The large westing, on the other hand, was almost certainly a normal feature, and due to the action of the land masses of the Malay Archipelago.

May 1893.

TABLE XI.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 13° W.	39%	2·9
Middle . .	S. 45° E.	67	2·8
South . .	S. 74° E.	72	3·5

Winds were very steady in the south and middle sections, and of moderate intensity in the south section but light in the middle section. They were more southerly in the middle section than in the south section. Winds were unsteady in the north section, but slightly stronger than in the middle section. The mean wind direction shifted from S. 45° E. to S. 13° W. (or 58° of westerly deflection) in advancing from the middle to the north section, or double the deviation produced in the months of January and February, when the winds were of approximately the same strength. It is hence almost certain that the air movement in the north section was not the direct and complete continuation of the air movement in the south and middle sections during the greater part of the month. The Westerly winds in the north section probably represent an irregular outflow from an area of light winds and ascensional movement, determined by the pressure conditions in India and the Indian Seas to the north, and hence of the same character as in the preceding month.

TABLE XII.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 43° W.	81%	3·5
Middle . .	S. 49° E.	52	2·4
South . .	S. 58° E.	70	3·5

South-east Trade winds prevailed in May 1893 over the south and middle sections, and the mean direction of the air movement was almost identical in the two sections. Winds were weaker and less steady in the middle than in the south section. In the north section moderate South-west winds of great steadiness obtained. The shift (of a right angle) from the South-east winds of the middle section to the South-west winds of the north section is far too large to be explained as a terrestrial rotational effect. The most probable explanation is that during the greater part of the month a narrow area of light and unsteady winds—the sink of the South-east Trades—lay over the equator, and that there was a drift out of it northwards into the Bay of Bengal, determined by the pressure conditions immediately to the north, and not by the general pressure conditions in Northern India, and more especially in Upper India.

June 1893.

TABLE XIII.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 51° W.	67%	3·4
Middle . .	S. 12° E.	85	3·6
South . .	S. 40° E.	97	4·1

South-east winds of great steadiness and average strength (4·1) prevailed in the south section. Winds were slightly less steady in the middle and north sections, but the data suggest clearly that these winds were due to the northward advance of an air current across the equatorial belt. The air movement or current was in fact steady, regular and continuous in its features, showing, as might be expected, a slight decrease of intensity and steadiness with its northward advance and recurvature. The deflection in advancing from the south to the north section (91°) is too large to be explained as an effect solely due to the earth's rotation.

TABLE XIV.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 59° W.	74%	3·1
Middle . .	S. 4° E.	69	2·9
South . .	S. 21° E.	70	3·2

The air movement was slightly weaker in the eastern than in the western half, but was of uniform steadiness throughout. As in the western half, the current was very largely deflected to the west in its northward advance; and the deflection can only to a partial extent be explained as a terrestrial rotational effect, and the remainder of the large deflection must be sought for in other actions. The greater part of the deflection was almost certainly produced by meteorological conditions in the Indian land and sea areas to the north.

July 1893.

TABLE XV.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 22° W.	59%	4·4
Middle . .	S. 17° W.	47	4·2
South . .	S. 41° E.	91	5·3

Strong South-east winds of great steadiness prevailed throughout the month in the south section. The data indicate that the air current was as in June continuous across the equatorial belt, and that it was deflected from west to east, as a current through 63°, nearly the same in amount as the deflection in the opposite current (of the North-east Monsoon) in the months of January and February. The deflection, however, occurred chiefly in the middle and not in the north section. The current was weakest and least steady in the section in which the deflection took place most rapidly.

TABLE XVI.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 88° W.	81%	4·1
Middle . .	S. 81° W.	41	3·5
South . .	S. 39° E.	74	3·4

The mean direction of the winds in the south section was almost identical with that in the corresponding section of the western half, but the air movement was somewhat less steady and considerably weaker (upwards of 33 per cent on the average of the month). Winds were stronger in the north and middle sections, and were very steady in the north section, where the mean wind direction was almost identical with that of the middle section. The most remarkable feature was the very large westerly deflection of the winds in passing northward from the south to the middle section. The mean wind direction in the south section was S. 39° E., and in the middle section S. 81° W., showing a westerly deflection of 120°. A reference to the Bay of Bengal Weather Charts suggests that this deflection was larger than usual, and that it was an exaggeration of a normal feature in the air movement of the equatorial belt in that month. As the conditions in the south section were apparently normal, the explanation of the very large deflection of the air current in its passage across the equatorial belt must be sought in the pressure conditions, and the general and special characteristics of the air movement in Burma, the Malay Peninsula, and the Indian land and sea areas during the month.

August 1893.

TABLE XVII.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 10° W.	50%	2·7
Middle . .	S. 33° E.	50	3·8
South . .	S. 52° E.	97	5·0

South-east winds of remarkable steadiness prevailed in the south section. They were almost identical in strength and direction with the winds of the previous month. The data indicate that the air current advanced northwards across the belt, and was deflected in passing through it by the same amount as in the preceding month (about 60°), but decreased considerably in force with its advance. The winds in the south and middle sections were more Easterly, and in the north section less Westerly, than in the preceding two months. The relation of this deflection to the rainfall in India is pointed out later on.

TABLE XVIII.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 46° W.	79%	3·7
Middle . .	S. 1° W.	68	3·4
South . .	S. 46° E.	73	4·1

The air movement in the south section was practically the same in mean direction as in the corresponding section of the western half. It was not so steady or strong as in that section, but was stronger than in the preceding month. The westerly deflection of the winds in advancing northwards was greater than in the western half, amounting to 92°, but occurred equally in passing from the south to the middle as from the middle to the north section. The data establish that the winds in the three sections were of similar strength and steadiness, and were hence almost certainly due to a continuous horizontal air movement. The data hence indicate or establish the advance of a steady and moderately strong horizontal air current across the equator, which was deflected rapidly to the east in its northward march, and more rapidly than can be explained as a terrestrial rotational effect.

September 1893.

TABLE XIX.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 53° W.	19%	2·1
Middle . .	S. 48° E.	62	2·8
South . .	S. 69° E.	77	3·6

Winds were much more Easterly in the south section than during the previous three months. They were much less steady and were much weaker (nearly 20 per cent) than in August. The winds in the middle section were evidently the horizontal continuation of the air movement in the south section. Winds were light and remarkably unsteady in the north section, and the mean wind direction was 101° more Westerly than in the middle section. These facts suggest a strong tendency to the establishment of a sink immediately to the north of the equator, and that the air movement to the south was similar in character to that which prevailed in May 1893.

TABLE XX.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
North . .	S. 68° W.	85%	3·7
Middle . .	N. 81° W.	38	1·9
South . .	S. 51° E.	55	2·4

In the south section of the eastern half winds were South-easterly, as in July and August. They were much weaker and less steady than in the corresponding section of the western half. Winds were very unsteady and very light in the middle section (averaging only 1·9 in force). The mean wind direction was West, with a slight northing. The facts suggest, as in the case of the western half, a marked tendency to the re-establishment of a belt of calms and light variable winds (in this

area immediately to the south of the equator) in this month. Winds were very steady, and were stronger than in the preceding months in the north section, and were also much stronger and steadier than in the corresponding section of the western half. The most noteworthy feature was their direction. Westerly winds predominated, and the mean direction was S. 68° W.

October 1893.

TABLE XXI.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
South . .	S. 63° E.	70%	3·6
Middle . .	S. 3° E.	32	3·1
North . .	N. 72° W.	32	3·0

The air movement in the equatorial belt changed in character in October. Steady and moderate East-south-east winds prevailed in the southern section, unsteady Southerly winds in the middle section, and equally unsteady West-north-west winds in the northern section.

TABLE XXII.—WINDS IN THE EASTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
South . .	N. 15° E.	20%	2·7
Middle . .	N. 58° W.	54	2·1
North . .	N. 79° W.	83	3·2

Winds were even more irregular in this area than in the western half. In the south section feeble but very unsteady winds prevailed, the mean direction being N. 15° E. In the middle and north sections Westerly winds predominated, and were remarkably steady in the north section, where the mean direction and strength were almost identical with those in the north section (western half).

The air movement in the equatorial belt in October 1893 was hence no longer a steady horizontal drift from south to north, subject to a westerly deflection south of the equator, and easterly deflection to the north. The South-east Trade winds prevailed on the average of the month to about lat. 2° or 3° S. in the western half, and to about lat. 5° or 6° S. in the eastern half. Winds were very unsteady immediately to the north of the limit of the South-east Trade winds, but farther north, *i.e.* to the north of lat. 2° S., in the eastern half, steady Westerly winds, with a slight northing, prevailed throughout the month. These winds were of average force 3, or of velocity 18 miles an hour, according to the relation given in Scott's *Meteorology*, p. 159.

November 1893.

TABLE XXIII.—WINDS IN THE WESTERN HALF OF BELT.

Section.	Mean Direction.	Steadiness.	Mean Force.
South . .	S. 68° E.	37%	3·4
Middle . .	S. 83° W.	31	3·6
North . .	S. 86° W.	35	3·4

Unsteady East-south-east winds prevailed in the south section. In the middle and north sections unsteady Westerly winds with a very slight southing obtained. The winds were approximately of the same strength in each section, and the existence of a narrow belt of calms and light winds, which is suggested by the observations from several ships, is not disclosed by the mean data.

TABLE XXIV.—Winds in the Eastern Half of Belt.

Section.	Mean Direction.	Steadiness.	Mean Force.
South . .	S. 64° W.	21%	2·9
Middle . .	S. 71° W.	73	4·0
North . .	N. 63° W.	64	2·8

Winds were on the mean of the month Westerly, with a slight southing, in the south and middle sections, and with a slight northing in the northern section. They were very unsteady in the south section, but steady in the middle and north sections. The most noteworthy feature was the strength of the Westerly winds in the middle section, where they averaged force 4, equivalent to a velocity of about 23 miles an hour.

The South-east Trades' influence hence extended as far north as lat. 4° S. in the western half, but was not felt in the eastern half. The most noteworthy feature of the air movement was the predominance of westerly winds, the absence of any well-marked belt of calms, and the prevalence of strong winds in the middle section, where they averaged force 4·0.

It is clear that in this month, as in October, the air movement cannot be explained as a mere horizontal transfer of air northwards across the equator, nor as a movement from the south into a sink, and a movement northwards and eastwards from that sink. It is hence probable that its direction was mainly determined by special conditions, meteorological and topographical, in the land areas to the east and north.

December 1893.

TABLE XXV.—Winds in the Western Half of Belt.

Section.	Mean Direction.	Steadiness.	Mean Force.
South . .	S. 30° E.	25%	2·4
Middle . .	S. 64° E.	14	2·7
North . .	N. 60° E.	53	2·4

The air movement in this month was different in character from that of the two previous months, and indicates the establishment of true North-east Monsoon winds in the Arabian sea. Light unsteady South-east winds prevailed in the south section. Winds were East-south-easterly on the average, but extremely variable in the middle section. In the north section light but fairly steady North-east winds obtained.

TABLE XXVI.—Winds in the Eastern Half of Belt.

Section.	Mean Direction.	Steadiness.	Mean Force.
South . .	S. 70° E.	22%	2·1
Middle . .	S. 75° W.	18	1·9
North . .	N. 27° W.	46	2·5

Light unsteady East-south-east winds prevailed in the south section. The middle section was an area of light Westerly and variable airs. Winds were much more unsteady in the north section than in the previous month, and were chiefly from North, with a moderate westerly element. The air movement in this area was evidently a transitional stage, accompanying the establishment of North-east Monsoon winds proper in the sea areas to the north of the equator. The only noteworthy feature was the persistence of Westerly winds in the north and middle sections until nearly the end of the month.

TABLE XXVII.—Mean Direction, Steadiness and Force of Wind in each Section of the Equatorial Belt, and of the whole Belt.

1893. Latitude.	Western Half.			Eastern Half.			Whole Equatorial Belt.		
	Mean Direction.	Steadiness.	Force.	Mean Direction.	Steadiness.	Force.	Mean Direction.	Steadiness.	Force.
	°	%		°	%		°	%	
Jan. 4° N to 0°	N 37 E	82	3·0	N 9 E	50	2·4	N 18 E	54	2·7
,, 0 ,, 4 S	N 14 E	65	3·2	N 48 W	36	2·4	N 7 W	44	2·8
,, 4 S ,, 8 S	N 17 W	62	2·3	N 56 W	27	3·0	N 27 W	46	2·7
Feb. 4 N ,, 0	N 40 E	76	3·6	N 18 W	62	2·5	N 8 E	59	3·1
,, 0 ,, 4 S	N 16 E	74	3·6	N 56 W	82	2·5	N 14 W	62	3·1
,, 4 S ,, 8 S	N 28 W	48	2·9	N 83 W	63	4·1	N 60 W	50	3·5
Mar. 4 N ,, 0	N 51 E	79	2·9	S 45 W	34	2·4	N 55 E	24	2·7
,, 0 ,, 4 S	N 28 E	29	3·0	S 57 W	42	2·6	N 55 W	8	2·8
,, 4 S ,, 8 S	N 80 E	7	2·0	N 21 W	41	2·2	N 14 W	26	2·1
Apr. 4 N ,, 0	S 68 W	27	2·5	N 56 W	61	1·7	N 66 W	37	2·1
,, 0 ,, 4 S	S 28 E	51	3·0	S 79 W	27	2·5	S 13 E	29	2·8
,, 4 S ,, 8 S	S 70 E	89	3·6	S 20 E	45	1·7	S 65 E	69	2·7
May 4 N ,, 0	S 13 W	39	2·9	S 43 W	81	3·5	S 37 W	58	3·2
,, 0 ,, 4 S	S 45 E	67	2·8	S 49 E	52	2·4	S 47 E	59	2·6
,, 4 S ,, 8 S	S 74 E	72	3·5	S 58 E	70	3·5	S 66 E	69	3·5
June 4 N ,, 0	S 51 W	67	3·4	S 59 W	74	3·1	S 56 W	70	3·3
,, 0 ,, 4 S	S 12 E	85	3·6	S 4 E	69	2·9	S 7 E	74	3·3
,, 4 S ,, 8 S	S 40 E	97	4·1	S 21 E	70	3·2	S 29 E	79	3·7
July 4 N ,, 0	S 22 W	59	4·4	S 88 W	81	4·1	S 68 W	61	4·3
,, 0 ,, 4 S	S 17 W	47	4·2	S 81 W	41	3·5	S 43 W	38	3·9
,, 4 S ,, 8 S	S 41 E	91	5·3	S 39 E	74	3·4	S 40 E	81	4·4
Aug. 4 N ,, 0	S 10 W	50	2·7	S 46 W	79	3·7	S 31 W	61	3·2
,, 0 ,, 4 S	S 33 E	50	3·8	S 1 W	68	3·4	S 15 E	58	3·6
,, 4 S ,, 8 S	S 52 E	97	5·0	S 46 E	73	4·1	S 49 E	84	4·6
Sept. 4 N ,, 0	S 53 W	19	2·1	S 68 W	85	3·7	S 61 W	40	2·9
,, 0 ,, 4 S	S 48 E	62	2·8	N 81 W	38	1·9	S 24 E	21	2·4
,, 4 S ,, 8 S	S 69 E	77	3·6	S 51 E	55	2·4	S 65 E	68	3·0
Oct. 4 N ,, 0	N 72 W	32	3·0	N 79 W	83	3·2	N 77 W	54	3·1
,, 0 ,, 4 S	S 3 E	32	3·1	N 58 W	54	2·1	S 85 W	22	2·6
,, 4 S ,, 8 S	S 63 E	70	3·6	N 15 E	20	2·7	S 81 E	34	3·2
Nov. 4 N ,, 0	S 86 W	35	3·4	N 63 W	64	2·8	N 67 W	53	3·1
,, 0 ,, 4 S	S 83 W	31	3·6	S 71 W	73	4·0	S 76 W	47	3·8
,, 4 S ,, 8 S	S 68 E	37	3·4	S 64 W	21	2·9	S 21 E	13	3·2
Dec. 4 N ,, 0	N 60 E	53	2·4	N 27 W	46	2·5	N 25 E	36	2·5
,, 0 ,, 4 S	S 64 E	14	2·7	S 75 W	18	1·9	S 46 W	6	2·3
,, 4 S ,, 8 S	S 30 E	25	2·4	S 70 E	22	2·1	S 53 E	21	2·3

The Burst of the Monsoon.

The charts show very clearly the changes in the air movement over the Indian Seas and the equatorial belt during the whole year, but more especially those which preceded and accompanied the establishment of the

South-west Monsoon in India in 1893. As already pointed out, one of the most marked features is the large and rapid change of meteorological conditions in the Indian land and sea areas which accompanies the establishment of the South-west Monsoon proper, and is termed in India the "burst of the Monsoon." To the inhabitant of the interior of India, the "burst of the Monsoon" represents a definite large change of the weather conditions, to a certain extent catastrophic in character, and is not a gradual development and intensification of conditions during a period of high and increasing temperature in the interior, either of India or Central Asia.

The chief features of the weather in the interior of India previous to the change are intense heat, great dryness of the air, skies obscured with dust, land-winds blowing furiously during the heat of the day and subsiding almost to a calm during the night. Subsequent to the change the weather is steadily marked by moderately high temperature, great humidity, much cloud, moderate steady winds of oceanic origin, and frequent rain. The change from the former to the latter conditions, or the "burst of the Monsoon," commences first in Southern India and extends northwards, and from the coast districts into the interior with a rapidity varying greatly from year to year, and is sometimes effected in the course of a few days over the whole of India. It commenced in the year 1893 in the Bombay coast districts in the second week of June, and was completed over Northern and Central India by the 19th and 20th of that month, and hence in an interval of two weeks. The mean data given in Table XXVIII. for four stations in the interior of India for the months of May, June and July 1893, will show the very large changes produced by the "burst of the Monsoon," which occurred in that year in the month of June.

TABLE XXVIII.

1893.	Mean Maximum Temperature.	Mean Daily Range of Temperature.	Mean Aqueous Vapour at 4 p.m.	Mean Humidity at 4 p.m.	Mean Amount of Cloud at 4 p.m.	Rainfall.
NAGPUR.	°	°	in.	%		in.
May	105·8	24·4	·497	26	5·5	0·81
June	93·0	15·9	·759	57	8·3	9·84
July	88·8	13·3	·822	70	9·5	7·59
ALLAHABAD.						
May	102·5	24·3	·512	28	3·0	0·77
June	95·8	16·6	·801	58	6·0	13·91
July	89·8	11·2	·934	73	8·7	13·12
LUCKNOW.						
May	99·4	24·4	·557	33	3·4	2·16
June	93·2	15·3	·826	60	4·9	9·55
July	89·6	12·0	·933	74	7·9	14·18
LAHORE.						
May	100·4	24·0	·547	31	1·9	1·90
June	100·5	19·9	·687	41	3·7	2·72
July	93·5	13·5	·913	65	4·7	7·36

The data in the preceding table show fully the very large permanent changes produced by the change known as the "burst of the Monsoon," which usually occurs at these stations on the average in the second or third week of June, in the temperature, humidity, and cloud conditions, and in the rainfall. Tables XXIX. and XXX. give data for the hottest period of the year 1893 (from May 15th to 21st) in Northern and Central India immediately preceding the "burst of the Monsoon" of 1893 in Southern India, and also for the same period of the month of June (15th to 21st) for comparison.

TABLE XXIX.—MAY 15TH TO 21ST.

STATION.	Mean Maximum Temperature.	Mean Aqueous Vapour, 4 p.m.	Mean Humidity, 4 p.m.	Mean Amount of Cloud, 4 p.m.	Rainfall.
	°	in.	%		in.
Nagpur . . .	107·5	·413	20	5·9	0·05
Allahabad . . .	108·7	·325	14	0	...
Lucknow . . .	106·7	·375	17	0	...
Lahore . . .	101·6	·518	27	1·9	0·05
Jacobabad . . .	108·9	·430	18	0·6	...

TABLE XXX.—JUNE 15TH TO 21ST.

STATION.	Mean Maximum Temperature.	Mean Aqueous Vapour, 4 p.m.	Mean Humidity, 4 p.m.	Mean Amount of Cloud, 4 p.m.	Rainfall.
	°	in.	%		in.
Nagpur . . .	86·1	·851	74	9	4·67
Allahabad . . .	89·8	·918	74	8	3·44
Lucknow . . .	90·4	·887	67	7	0·98
Lahore . . .	99·2	·794	45	3	1·05
Jacobabad . . .	114·3	?	?	?	...

The data of Tables XXIX. and XXX. illustrate fully the great difference between the meteorological conditions of the two periods, separated by an interval of three weeks (*i.e.* from May 24th to June 15th, 1893), during which the change known as the "burst of the Monsoon" occurred in that year.

Pressure Conditions.

The preceding data show that the hot weather conditions of excessive temperature, dryness of the air, and absence of cloud and rainfall were almost identical in their intensity at these five stations, representing the greater part of the interior of Northern and Central India. The highest temperatures are usually registered in India during the last fortnight of May, and in most years between the 20th and 25th. The hottest day of the year 1893 in North-Western India was May 24th (or the 24 hour period preceding 8 a.m. of the 25th). An examination of the charts for 1893 shows that during nearly the whole of the hot period, or from the month of March to the third week of May, 1893, little or no change occurred in the pressure conditions over the south of the Arabian Sea and the equatorial belt. During the whole of that period the pressure at Zanzibar, and near the equator in the western half, was steadily about 29·95 in. Pressure, on the other hand, decreased in the interior of

India by a series of oscillatory changes. Occasionally during this period very steep gradients prevailed in the Peninsula and near the coasts of the Bay and the Arabian Sea. These gradients, however, only affected the winds in India and the sea area in the immediate neighbourhood of the coast districts, whilst in the open sea, more especially in the centre and south of the Arabian Sea, light unsteady winds and feeble pressure gradients held steadily throughout.

A rapid change, however, occurred in the equatorial belt in the third and fourth weeks of May 1893. Pressure increased considerably, more especially when it is considered that the annual pressure changes at and near the equator are very small in amount. Table XXXI. gives mean data for Zanzibar from actual observations, and also for the Seychelles, as determined from the isobars on the charts. It should be noted that in the eastern half the isobars in the charts were drawn in accordance with the reduced observations taken at Singapore and Penang, but there are very strong reasons for believing that there was a very considerable difference between the barometers at these stations and the Calcutta standard barometer—the exact amount of which I hope to ascertain shortly.

TABLE XXXI.—MEAN 8 A.M. PRESSURE AT ZANZIBAR AND SEYCHELLES.

1893.	Zanzibar (actual) reduced to Sea Level and constant Gravity.	Seychelles (probable as determined from Charts).
	in.	in.
April 1–7	29·94	29·94
,, 8–14	29·91	29.92
,, 15–21	29·90	29·90
,, 22–28	29·97	29·93
May 1–7	29·97	29·94
,, 8–14	29·99	29·96
,, 15–21	30·04	29·99
,, 22–28	30·04	30·02

At the same time winds strengthened in the equatorial belt, and finally a strong current advanced from the belt northwards towards India, carrying rainy, squally weather, and also modifying the pressure distribution. This change, when completely effected in June 1893, was more or less permanent during the next three months, during the whole of which period moderately steep and fairly uniform gradients obtained from lat. 8° S. to the northern limits of the Arabian Sea and Bay of Bengal. The chief difference between the pressure distribution in July 1893 (*i.e.* the rainy season), and the distribution in May 1893 (*i.e.* the hot weather season), was not in India or in the sea areas near the Indian coasts, but in the south of these sea areas and the equatorial belt. Two charts are given for comparison.[1] Fig. 1 is for May 2, 1893. Temperature had been excessive for some days previously, the maximum at Jacobabad, for example, being 118° on the afternoon of the 1st. A low pressure area (or hot weather disturbance following a large rise or excess of temperature

[1] It should be noted that these charts differ slightly from the charts for those days published in the Indian Monsoon Area series, due to the correction of the Singapore and Penang barometric readings.

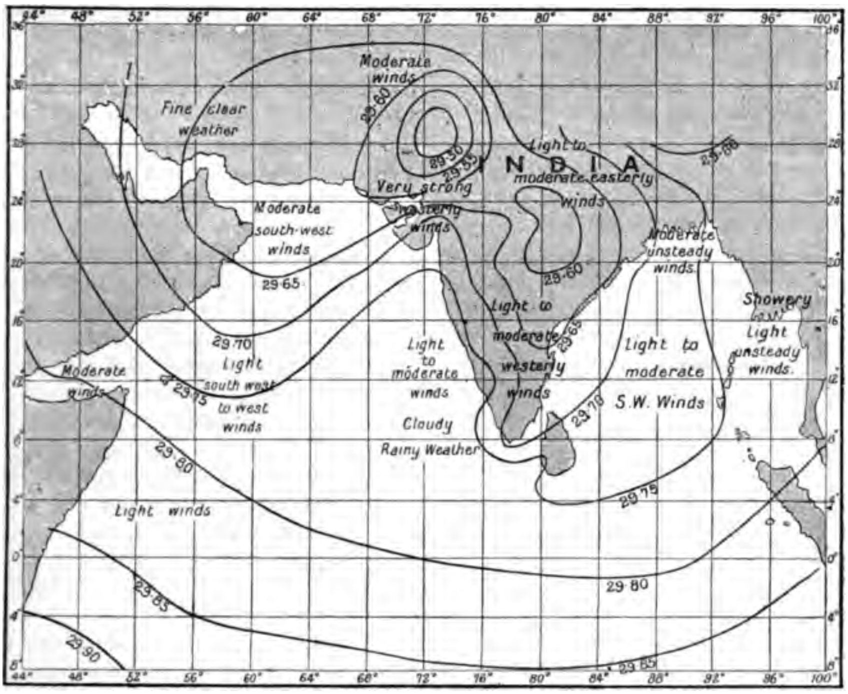


FIG. 1.—Chart of Indian Monsoon Area, May 2, 1893.

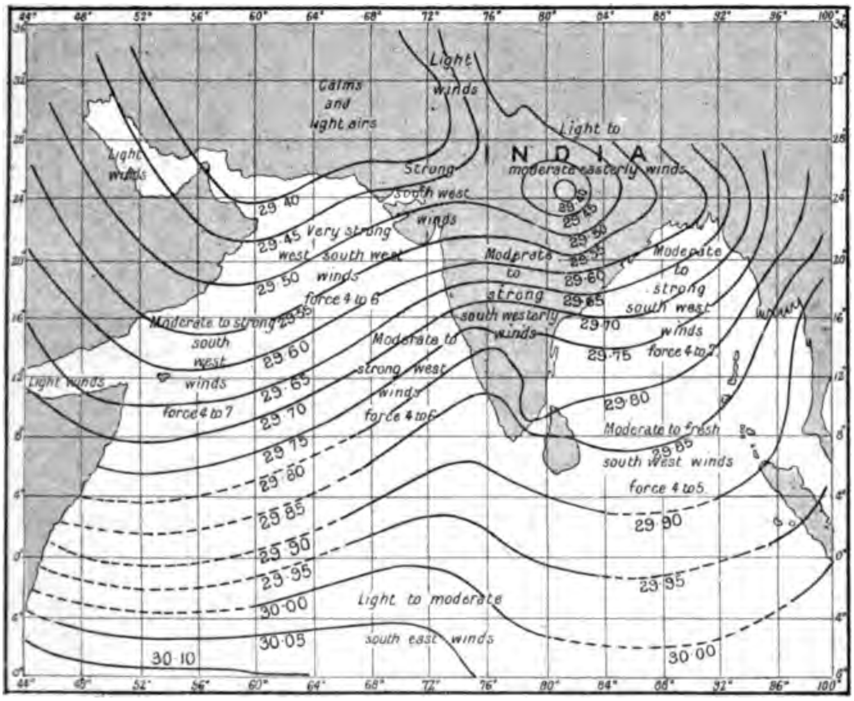


FIG. 2.—Chart of Indian Monsoon Area, June 21, 1893.

in Upper India) had formed in Sind, which advanced eastwards during the next 48 hours to the Punjab hills, and gave numerous duststorms and thunderstorms in North-Western India. Fig. 2 is for June 21, 1893, when the South-west Monsoon was fully established over the Indian land and sea areas, and was giving more or less general rain over India and Burma. In the first case the isobars run parallel to the coast, and are directly related to and evidently the product of, the thermal conditions in the interior of India, and are closely packed together in the coast districts and Upper India. In the second case they are placed at fairly regular intervals over the whole sea area and the Peninsula, and run from east to west, or nearly parallel to the lines of latitude, and are directly related to the prevalence of a strong, steady and massive air current from south to north over the whole area, with more or less easting or westing determined by various conditions and actions. This distribution of pressure is clearly not the product of the antecedent or the actual thermal conditions of India. It is this change in the pressure distribution which marks the transition from the hot weather to the rainy season, and which inaugurates or accompanies the "burst of the Monsoon."

Air Movement.

The following states one or two of the more striking features of the Monsoon air movement, during the South-west Monsoon period—June to September 1893. The air movement across the equatorial belt was stronger in the western than in the eastern half. It is sufficient to give mean data for each half, and not for the smaller divisions of each:—

TABLE XXXII.—Mean Force of the Winds in the Equatorial Belt.

1893.	Western Half. (A)	Eastern Half. (B)	Ratio. A : B
June . .	3·7	3·1	1·19
July . .	4·6	3·7	1·24
August . .	3·8	3·7	1·03
September .	2·8	2·7	1·03

The contrast was strongly marked in the months of June and July. The Monsoon currents in India were weak in August, and it is probable that in September there is usually a tendency for the current in the eastern half to gain in strength relatively to that in the western half.

The following table gives corresponding data for the steadiness of the winds:—

TABLE XXXIII.—Mean Steadiness of the Winds expressed as a Percentage.

1893.	Western Half.	Eastern Half.
June	83%	71%
July	66	65
August	66	73
September . . .	53	59

It would hence appear that the air movement in the two halves of the equatorial belt was about equally steady during this period.

The data establish that the current across the equator in 1893 increased rapidly in strength and steadiness in June, and was strongest and steadiest in July. It thence decreased in both respects, at first slowly in August, and rather rapidly in September, and was weak and unsteady at the commencement of October. These changes were directly related to the changing gradients in the Indian Ocean, where they reach their maximum value or intensity in July.

An examination of the data for the equatorial belt also shows that during the South-west Monsoon period of 1893 (June to September) the strength of the air current across it varied to some extent, and that its larger fluctuations were related directly to the general distribution and amount of the rainfall in India. The variations were exhibited most fully in the South-east Trade winds in the south belt. Table XXXIV. gives the mean force of the winds in the western half of the equatorial belt, and also in the southern division of that area, grouped according to the larger periods into which the South-west Monsoon of 1893 may be divided according to the rainfall in India, and hence also of the general or mean force of the currents in the Indian seas.

TABLE XXXIV.

1893.	Mean Force of Winds in Western Half of the Equatorial Belt.	Mean Force of Winds in the Southern Section of the Western Half.	General character of the Rainfall during the Period in India.
June 1–11	3·7	3·8	Period of establishment of Monsoon winds in the Indian seas and in India.
,, 12–30	3·7	4·4	Period of heavy general rainfall.
July 1–12	5·0	5·8	Strongest and most general burst of rainfall during whole period.
,, 13–20	4·5	5·3	General moderately heavy rain.
,, 21–31	4·4	4·7	Moderate rainfall, chiefly in the Peninsula, North-East India, and Burma. Partial break in Upper India.
August 1–12	4·4	5·3	Period of general and moderately heavy rain.
,, 13–23	3·4	4·5	Period of moderate and partial rainfall. Marked break in rains in Upper India.
,, 24–31	3·7	5·0	Period of moderately heavy and general rain.
Sept. 1–9	3·4	4·3	Period of moderate and general rainfall.
,, 13–21	2·8	3·4	Period of slight to moderate general rain.
,, 22–30	2·3	3·2	Period of light and partial rain, more especially in North-Western India.

The number of observations from which these mean values of the force of the winds in the equatorial belt in the preceding table are obtained is not large, but they give very consistent results, and are sufficient to establish that the rainfall in India during the South-west

Monsoon of 1893 was heaviest and most general, when the air current across the equatorial belt was strongest, and *vice versâ*. Any large variation in one of these elements was in fact reproduced clearly in the other.

Table XXXV. gives the actual mean force of the winds experienced by vessels in the western and eastern sections of the equatorial belt in the months of June to September 1893, during which the Monsoon currents prevailed generally in the Indian land area, and also the mean intensity of the winds in the Arabian Sea and Bay of Bengal, determined from the data given in the Daily Weather Reports and Charts of the Indian Monsoon area for 1893, and the average rainfall in India during the same months.

TABLE XXXV.—MEAN FORCE OF WINDS.

1893.	Equatorial Belt.		Arabian Sea.	Bay of Bengal.	Mean Rainfall in India.
	Western Half.	Eastern Half.			
					in.
June . .	3·7	3·1	4·0	3·7	11·89
July . .	4·6	3·7	4·2	3·5	12·78
August . .	3·8	3·7	3·8	4·0	8·26
September .	2·8	2·7	3·2	3·5	9·62
Mean . .	3·7	3·3	3·8	3·7	

It should be remembered that all these means are approximate, and are calculated on the supposition of assigning equal values to all observations, and without regard to their distribution over the area in which they were taken.

A comparison of the data of these tables indicates that the air movement in the western half of the equatorial belt averaged 3·7 in force, corresponding according to the tables for converting the Beaufort scale of wind-force into ordinary velocity units usually given in meteorological works,[1] to a velocity of nearly 22 miles an hour, and the mean intensity of the air movement across the equatorial belt was almost identical with that in the Arabian Sea during the same period (3·8), and also in the Bay of Bengal (3·7). The equatorial belt was (as is shown by an examination of the whole of the data) in no part of it an area of light variable airs and calms, but one of moderately strong and steady winds. The strength of the current blowing across the equatorial belt during this period varied considerably, and was greatest when the Monsoon currents were strongest in the Bay of Bengal and the Arabian Sea, when also India received the greatest rainfall from these currents. The whole of the data establish that the current across the equatorial belt in the months of June to September varied *pari passu*, with the strength of the Monsoon winds in the Indian seas and the rainfall in India. It may also be noted that when the current was strongest in the equatorial belt and the Indian seas, weather in the equatorial belt was generally fine, and skies were frequently clear for days, and squalls were of comparatively rare occurrence (more especially in the western half). This inverse relation between the rainfall in India and the equatorial belt is further illustrated by Table XXXVI. of rainfall at the Seychelles, lat. 4° 37′ S. in 1894—the only year for which data are

[1] *Vide* Scott's *Elementary Meteorology*, 2nd Edition, p. 159.

available (the observatory at Port Victoria being established in February 1894).

TABLE XXXVI.—RAINFALL AT SEYCHELLES, 1894.

	in.		in.
January . . .	?	July . . .	2·33
February . . .	?	August . . .	4·59
March . . .	6·56	September . .	2·40
April . . .	4·96	October . .	3·97
May . . .	2·13	November . .	13·97
June . . .	4·92	December . .	9·88

Another noteworthy feature was the steadiness of the winds in the equatorial belt during the period June to September. Table XXXVII. gives data showing the force and steadiness of this current during the period June to September in the eastern and western portions of that area. Corresponding data are given for Bombay, Saugor Island, Port Blair, and Minicoy for the same months—with a view to a comparison of the force and steadiness of the current in the equatorial belt and the Indian seas, from a slightly different standpoint to that in the preceding comparison.

The stations of Bombay, Saugor Island, and Minicoy are specially selected, as the exposure of their wind instruments is unusually satisfactory, and they hence represent, so far as land stations can possibly do so, the strength of the air movement in the adjacent sea areas. Port Blair is situated on the east side of the South Andaman Island, and is to some extent protected from the South-west winds by hills of 1000 to 2000 feet in elevation.

TABLE XXXVII.—FORCE AND STEADINESS OF THE WIND.

1893.	Force.						Steadiness.					
	Western Half.	Eastern Half.	Bombay.	Saugor Island.	Port Blair.	Minicoy.	Western Half.	Eastern Half.	Bombay.	Saugor Island.	Port Blair.	Minicoy.
							%	%	%	%	%	%
June	3·7	3·1	2·3	3·4	0·5	3·2	82	71	50	77	59	92
July	4·6	3·7	2·3	2·5	0·5	3·8	66	65	74	76	71	92
August	3·8	3·7	2·3	2·3	0·9	3·1	66	73	85	43	84	93
September . . .	2·8	2·7	1·8	2·0	1·5	2·1	53	59	52	38	83	89
Mean . . .	3·7	3·3	2·2	2·5	0·9	3·0	67	67	65	59	74	92

The mean percentage steadiness of the equatorial belt for the whole period is 67, slightly greater than for Bombay (65) and for Saugor Island (59), but less than at the insular stations of Port Blair and Minicoy. It is hence clear that the air movement across the equatorial belt is as steady on the average of the whole period as the Monsoon flow into India across the Bombay and Bengal coasts, and probably also as in the Arabian Sea and the Bay of Bengal.

Connection of South-west Monsoon Air Movement with the South-east Trade Winds.

The preceding discussion has shown that, in 1893 at least, there was a strong flow or air movement across the equatorial belt during the Monsoon period, June to September, and that this flow was in all its more important features, more especially in its strength, steadiness, and the variations in these elements, similar and directly related to the corresponding features of the Monsoon currents in the Indian seas and India.

The evidence of the year 1893 is thus strongly in favour of the supposition, or theory, that the South-west Monsoon currents in the Indian seas are the direct continuation, north of the equator, of the horizontal movement of the South-east Trade winds; and also establish that the larger variations in the strength of the South-east Trades near the equator, during the Monsoon period, are reproduced in the Monsoon currents in the Indian seas from June to September.

An important feature (and one which, so far as I am aware, has not yet been discussed) is the way in which the change in the South-east Trades circulation from that obtaining in March to that of June, by which the area of ascensional movement is transferred from the equatorial belt to the areas of Monsoon rainfall in Abyssinia, India, and Burma is effected. So large a change in a vast atmospheric current like that of the South-east Trades over the Indian Ocean, can evidently be produced only by the prolonged actions of large forces. The nature of the change in 1893 has been fully shown in the discussion on the winds in the equatorial belt. There were two stages in the change. The first stage was what might be termed preparatory. During this period, the ascensional movement over the equatorial belt continued in diminishing volume and strength, whilst an irregular and increasing outflow took place to the north (determined by pressure conditions in the Indian land and sea areas). This increasing northerly outflow, it may be noted, accounts for the decreasing intensity of the ascensional movement over the equatorial belt during this stage. Finally, during the second stage, in consequence of the increasing pressure gradients to the south in the Indian Ocean, and also to the north in the Indian sea and land areas, the ascensional movement broke down with more or less rapidity, and the mass of the South-east Trades was then transferred by a continuous slow movement northwards. It was this second stage which gave rise to the series of phenomena known as "the burst of the Monsoon." This change usually occurs in the equatorial belt during the last fortnight of May, and is one of the most striking features of the meteorology of the Indian Monsoon area.

The change in the last fortnight of May, viz. the breaking down of the ascensional movement over the equatorial belt, and the extension of the movement northwards (including the transfer of the area of ascensional movement from the equatorial belt to the interior of India), so far as can be judged, explains satisfactorily the large phenomena connected with the establishment of the Monsoon in India and the Indian seas. The pressure changes in the equatorial belt and the Indian seas are strongly in favour of this explanation.

Pressure increases in the centre and south of the Indian Ocean, and the gradients thus favouring the South-east Trades increase from February

onwards, and reach their maximum in July (thus coinciding with the period of strongest winds in the equatorial belt and the Indian seas). The most remarkable change in the pressure conditions of the Indian Ocean and its northern arms is a rapid increase of pressure of about a tenth of an inch in the equatorial belt in the last half of the month of May. It is shown as clearly in the 1894 as in the 1893 series of charts. This increase of pressure is easily explained on the supposition that it is only not merely coincident in time, but that it is a result of the more or less complete break down of the ascensional large movement over that area.

Hence during this interval there are large actions in operation tending to modify the air movement over the equatorial belt. The first is increasing flow from the south, due to increasing strength of the South-east Trades accompanying the general increase of the gradients due to the changing temperature conditions in the Indian Ocean, or southern hemisphere generally. The second is the increasing outflow to the north, determined by the increasing gradients in the Indian seas and India determined by the temperature conditions of the northern hemisphere (or the old world continental mass), and inverse in character to those of the southern hemisphere. The combination of these tends first to diminish the uptake, and to increase to some extent the mass of air, and hence its pressure over the equatorial belt. The conditions become more and more unstable, and at length reach a critical point, when the two movements join up and determine a large and rapid rush northwards, due to the complex combination of conditions and actions.

Transition from the South-west Monsoon to the North-east Monsoon.

The phenomena of the transition from the South-west Monsoon to the North-east Monsoon in the Indian seas and the equatorial belt are in some respects similar, and in others inverse, to those which mark the opposite transition, viz. from the North-east to the South-west Monsoon. In the first period, April to May, the extension of the South-east Trades into the Indian area is due to increasing strength, and is therefore finally impulsive and catastrophic in character; whereas the withdrawal of the current from the Indian area is due to decreasing strength, and hence occurs comparatively quietly.

The air movement in the equatorial belt and to the north during this second transition period (October to December) is characterised by the same general features as that of the first transition period. It is unnecessary to discuss them in detail, but the following gives a brief statement of the more important:—

(1) The South-east Trades fall off in strength, and the northern limit withdraws slowly southwards.

(2) The area immediately to the north of the northern limit of the South-east Trades becomes an area of light and variable winds, these features becoming more marked with the advance of the period.

(3) This change takes place more rapidly in the western half of the equatorial belt than in the eastern half. This is most probably due to the fact that the Arabian Sea is not shut off from the Persian area by large mountain masses in the way that the Bay is from Thibet or Central Asia. The air-drift from the north is due to decreasing temperature in

Central and Western Asia, and so extends more rapidly in the Arabian Sea than in the Bay.

(4) Immediately to the north of this area of unsteady winds Westerly winds obtain, thus indicating that a drift or northward outflow from that area continues during this period. This drift, however, diminishes in intensity from October to December, and is far more marked, and prevails much longer in the eastern than in the western half.

(5) Finally, in December North-east winds are established in the Indian seas, and extend southwards to the area of light variable winds over the equatorial belt; and the normal circulation of the Trades is finally re-established.

The change from the circulation of the Monsoon period to that of the transition period usually commences in September. It was in September 1893 (and probably always) marked by pressure changes in the equatorial belt, inverse in character to those which preceded the "burst of the Monsoon" in May 1893. Table XXXVIII. gives the barometric pressure at 8 a.m. for Zanzibar and the Seychelles for every seventh day from September 1st to the end of October, and also the mean for November.

TABLE XXXVIII.—BAROMETRIC PRESSURE AT ZANZIBAR AND SEYCHELLES.

1893.	Zanzibar (actual). in.	Seychelles (calculated). in.
September 1	30·098	30·06
„ 8	30·115	30·07
„ 15	30·073	30·06
„ 22	30·020	30·02
„ 29	29·989	29·96
October 6	30·017	29·98
„ 13	29·997	29·97
„ 20	29·996	29·97
„ 27	29·995	29·97
November, Mean	29·985	29·96

The data in Table XXXVIII. show that the high pressure which was established in the last fortnight of May held until the middle of September. Pressure then decreased a tenth of an inch during the next fortnight, and was remarkably steady throughout October and November, averaging 30·00 in. at Zanzibar and 29·97 in. at the Seychelles. This change of pressure initiated or preceded the first change in the air movement over the equatorial belt described above, and was preliminary to the re-establishment of the uptake over the equatorial belt.

Air Movements in the Equatorial Belt.

In the following is given a brief summary of the chief facts of the air movement in the equatorial belt, and the inferences respecting the nature of that motion, derived from an examination of the 1893 Indian Monsoon area charts.

Throughout the whole year, *i.e.* during the North-east, as well as the South-west Monsoon, the air movement is stronger and steadier in the western than in the eastern half. This contrast between the air move-

ment in the eastern and western portions of the equatorial belt is in accordance with the known conditions of that movement. The South-east Trades current from its direction should advance in greater volume, and be less modified by the actions of the neighbouring land masses in the north-west than in the north-east of the Indian Ocean. This should hold not only during the North-east Monsoon, but even more strongly in the South-west Monsoon, when the South-east Trades are continued as a horizontal current in the equatorial belt.

In the months of January and February the North-east Monsoon winds in the western half of the equatorial belt are continued south across the equator to about lat. 8° S. (on the mean of the period). The winds are little influenced by the conditions of the neighbouring land area. The mean force of the winds before they are absorbed into the ascending current of the belt of calms is 3·1. They are deflected westwards, in accordance with theory, from a mean direction in the north section (mean lat. 2° N.) of N. 25° E. to a mean direction of N. 25° W. in the south section (mean lat. 6° S). The amount of this deviation accords fairly with the results of calculation based on the supposition that it is a result of the earth's deflectional action due to its rotation, and might therefore be taken as a measure of the amount of deflection due to that action on an air current (force 3) advancing northwards or southwards over a sea area between these limits of latitude.

The winds in the eastern half exhibit a much larger westerly deflection than this amount. This additional deflection is almost certainly a result of the heated land masses of the islands in the Malay Archipelago in modifying the air movement.

The belt of calms, which in the months of January and February lies to the south of the southern section of the equatorial belt, is in that section in March, and the air movement is very light and unsteady.

In March, as in the preceding two months, Westerly winds predominate in the eastern half, and are clearly due to the presence of the large insular areas of the Malay Archipelago.

The air movement in the equatorial belt in the months of April and May is much more complex than in the preceding three months. South-east winds extend northwards across the south section in April, and the middle section in May. Immediately to the north of the South-east Trades in both months winds are light and variable, but to a less extent than in March. North-easterly winds, however, no longer obtain to the north of this belt of light and variable winds. The air movement is comparatively steady in that area, more especially in the eastern half, and increases in steadiness from April to May, and is from west, with more or less southing. These South-west winds therefore appear to be a gentle outflow from the equatorial belt of light variable winds (which represent the termination of the South-east Trades as a horizontal air current and its continuation in the vertical direction) to the north, determined by the feeble but increasing pressure gradients in the Indian seas produced by the temperature conditions in India. The increasing outflow is not strong enough for some time to break up the ascensional movement in front of the South-east Trades, which has been an integral feature of that circulation during the previous four months. Hence it appears that during these two months the South-east Trades circulation extends northwards to the

equator, but is otherwise unchanged in character. It is mainly continued upwards by ascensional movement over a narrow belt of light variable winds near the equator. From this belt (serving as a reservoir) there is, however, an outflow towards the north, increasing slowly in intensity and steadiness. The direction of this outflow is determined mainly by the temperature and pressure conditions in the Deccan and Malay Peninsula and Archipelago. This north-easterly feeble advance of humid winds over a considerable expanse of ocean surface gives frequent thunder-showers in Eastern India and Tenasserim. Mr. Blanford's theory of the belt of calms serving as a huge reservoir almost certainly holds true for the hot weather (or transitional) months of April and May. The character of the air movement in the equatorial belt changes very rapidly in a brief period, which varies slightly in time from year to year. It, however, generally occurs in the last week or fortnight of May. It is this large and rapid change which initiates the "burst of the Monsoon" in India. The character and phenomena of the changes have been fully described above, and need not be repeated here. But the chief result of these changes is to give a steady and continuous horizontal air current from south to north across the equatorial belt, and its northward extension over the whole Indian area.

The current across the equatorial belt holds more or less steadily from June to September. It is (probably), as a rule, strongest in July, when India generally receives the heaviest rainfall of the season. It supplies aqueous vapour to three large areas of precipitation, viz. (1) the basins of the White and Blue Nile in Africa, (2) India, and (3) Burma and Further India. It is probable that prolonged successive rainfall in one of these areas during a part of the Monsoon period will diminish the rainfall in the other areas; and so the variations of the rainfall over the whole field of precipitation of this humid current during the Monsoon season will be compensatory to a considerable extent. It is also probable that any large variations in the distribution of the rainfall from the normal during any part of the rainfall season, will be due to, or accompany, variations in the strength and direction of the Monsoon currents, and hence also of the current across the equatorial belt. The relations described below between the deficient rainfall in India during the month of August 1893, and the abnormal easting of the winds in the western half of the equatorial belt, is probably an example of these relations.

The current across the equatorial belt continues unchanged in character until about the middle or end of September. A rapid decrease of pressure of about a tenth of an inch reduces it to an average of about 29·95 in., or to the same amount as before the "burst of the Monsoon." Winds become light, unsteady, and variable in direction in that area, whilst Westerly winds continue to the north, and feed into the area of precipitation in the Bay and the Peninsula. In fact the character of the air movement is generally similar to that of April and the first half of May; and Mr. Blanford's explanation of the equatorial belt of light winds serving as a reservoir for inflow from the south and outflow to the north, is almost certainly applicable to this period as to the pre-Monsoon period. North-east winds are gradually established in the Indian seas, and finally extend down to the equator in the month of December, when

the air circulation is that of the South-east and North-east Trades, with an inter-Trade region of light winds.

An important conclusion from the examination of the 1893 data is that the "burst of the Monsoon" is produced by the advance of a humid current from the equatorial belt (the continuation of the South-east Trades), and that the Monsoon rains are due to the invasion of India by this current, and not to the gradual development of a hot weather air circulation set up in April and May in Northern and Central India by the excessive temperature conditions of the period. The South-west Monsoon forecasts are in part based on this important principle, of which the following is a statement and explanation as given in the forecast for the year 1891 :—

> The motion of the South-west Monsoon current is hence a horizontal movement from the Indian Ocean across the Arabian Sea and Bay of Bengal into India and Burma. This vast mass of humid air is impelled northwards by forces due to differences of pressure over the whole tropical region of Southern Asia and the Indian Ocean. It is evident that if there are differences from year to year in the strength of the South-east Trades, or in the pressure gradients over the sea area to the south of India and Burma due to causes in operation there, they will affect the general strength of the Monsoon.
>
> Whether there are such differences from year to year has not been proved in the absence of accurate observations over the sea area, but there are various reasons for believing that they do occur. If this be the case, they form one of the factors which determine the general strength of the Monsoon currents.
>
> Again, the conditions in India and Burma before and at the time of the advance of the Monsoon differ very largely from one year to another. It is evident that these prevailing conditions will modify and determine, to some extent at least, the extension of the Monsoon currents over India at the time of their advance. These conditions must give a certain set to the air currents. Also in virtue of well known laws of air motion or of fluid motion, the currents by their subsequent action and motion will tend during their existence to maintain the peculiarities set up by the conditions in existence at their commencement. The forecast in the final paragraphs is hence partly based on the important principle indicated above, viz. that the meteorological conditions prevailing in India before and at the commencement of the Monsoon mainly determine the character and extension of the current, and thus impress upon it features which are more or less permanent throughout its whole period of prevalence, and are largely influential in determining the accompanying rainfall, and may therefore be used as indications of the probable distribution of that rainfall.

The examination of the 1893 data confirms the chief principle, or supposition on which these forecasts are based.

Rainfall in India during the South-west Monsoon.

One of the objects in view in collecting and tabulating meteorological data of the Indian seas is to ascertain the causes of the larger variations of the rainfall in India during the South-west Monsoon period, more especially in those cases where the meteorology of the land area does not disclose an adequate cause for the weakness of the Monsoon currents, and the prolonged breaks in the rain which occasionally occur during the South-west Monsoon period.

The discussion of so important a question can only be properly attempted when observations for several years have been collected. The data for 1893, however, throw some light on the probable causes of the only important break in the rains in 1893. The Monsoon currents were steady in June, July and September 1893, and the rainfall in India, on the whole, normal and well distributed. The rainfall of the month of August 1893 was, on the other hand, very deficient, and the Monsoon currents in India very light. The deficiency in the rainfall (relatively to the normal) was greatest in Upper India, and decreased in percentage amount eastwards and southwards, as is shown in Table XXXIX.

TABLE XXXIX.—Variation of Rainfall from Normal, August 1893.

Meteorological Province.	Mean. in.	Percentage.
Indus Valley and North-west Rajputana .	−1·32	−55
Upper sub-Himalayas	−5·21	−47
East Rajputana, Central India, and Gujarat	−3·43	−36
Gangetic Plain and Chota Nagpur . .	−3·60	−31
Bengal and Orissa	−1·55	−11
West Coast	−5·37	−28
South India	−1·44	−25
Deccan	+2·08	+24
Burma Coast and Bay Islands . . .	+0·25	+1
Assam	+3·49	+22

The large and general deficiency of the rainfall in August was due to two breaks in the rains over North-Western and Central India, lasting from the 1st to the 6th, and from the 13th to the 23rd, during which practically no rain fell in North-Western India. This deficiency was not compensated by a corresponding excess in any other part of the Indian area, and the meteorology of India for the month throws little or no light upon the causes of this large general deficiency of rainfall.

Table XL. gives the mean wind direction in the three sections of the western half of the equatorial belt for the months of June, July, and August.

TABLE XL.—Wind Direction, June to August 1893.

Section.	June.	July.	August.
South . .	S. 40° E.	S. 41° E.	S. 52° E.
Middle .	S. 12° E.	S. 17° W.	S. 33° E.
West . .	S. 52° W.	S. 22° W.	S. 10° W.

Rise of the Nile and Rainfall in India.

The wind data for August show that the air current across the equatorial belt differed considerably in mean direction in that month from that in June and July. Winds were in August much more Easterly or less Westerly, thus indicating that the current was determined in larger amount to the Upper Nile and Abyssinia of precipitation areas, and less directly towards the Indian area than in the previous two months. This suggests that the weakness of the current in India was probably due to

an increased flow towards equatorial Africa and Abyssinia. There are no available rainfall data for that area, and so it is not possible to ascertain whether the deficiency in India accompanied excess in the basin of the Upper Nile, but it appears to be probable, and the relation between the distribution of the rainfall in different parts of the areas depending upon the South-west Monsoon current deserves full investigation.

The humid current crossing the equator as the continuation of the South-east Trades undoubtedly gives general heavy and frequent rain to three large land areas, viz.—

(1) Abyssinia and the Upper Nile Basin and the equatorial lakes district, in which the Nile takes its rise.

(2) India.

(3) Burma and perhaps Indo-China and the Malay Peninsula.

In a paper on "The Nile" by Mr. Willcock, Director-General of the Reservoirs of Egypt, given in the Report of the Chicago International Meteorological Congress, it is stated that the rainfall in the equatorial lake district and Abyssinia averages about two metres, or eighty inches, annually. The rainfall in the equatorial lake districts occurs between March and December, and in Abyssinia between June and September, and is usually heaviest in August (the month when breaks in the rains are most frequent in India). Mr. Willcock says that famine years in India are generally years of low flood in Egypt, and hence of probably deficient rainfall in Abyssinia. This remark suggests that the large variations in the Monsoon rainfall are probably common to the whole area of precipitation; and further, that the rainfall over the whole area, fed by the humid current crossing the equator, depends for its general character upon the strength of that stream.

TABLE XLI.—VARIATION OF HIGH FLOOD LEVEL OF THE NILE AND RAINFALL IN INDIA.

Years.	Variation of high flood level of year from mean high flood level at Assouan.	Variation of high flood level of year from mean high flood level at Cairo.	General character of South-west Monsoon Rainfall in India.	Approximate variation of South-west Monsoon Rainfall in India from normal.
	in.	in.		in.
1875	+18·1	+29·1	Large defect	−3·37
1876	+30·7	+39·0	Very large defect	−9·27
1877	−59·1	−68·9	Excess	+2·94
1878	+49·2	+73·3	Excess	+2·66
1879	+27·2	+35·4	Moderate defect	−2·60
1880	− 3·2	−24·4	Moderate excess	+2·44
1881	+ 9·5	+26·8	Moderate excess	+2·06
1882	+ 3·9	−26·8	Moderate defect	−1·68
1883	+11·0	+26·8	Moderate excess	+2·48
1884	− 6·7	− 7·1	Slight excess	+0·85
1885	+ 5·9	− 1·2	Moderate excess	+1·40
1886	+ 5·5	−11·0	Moderate	+0·13
1887	+35·8	+50·4	Slight	+0·64
1888	−32·3	−53·6	Large excess	+3·35
1889	+18·1	+ 1·6	Moderate excess	+1·34
1890	+32·3	+16·5	Large defect	−4·88 *
1891	− 2·4	+ 0·8	Moderate excess	+1·62
1892	+38·6	+45·2	Slight excess	+0·96

* There was extraordinarily heavy rain in Abyssinia in September in this year.

In order to test this so far as is at present possible, Table XLI. has been drawn up. Columns 2 and 3 give the variations of the maximum flood level of the Nile, as shown by the gauges at Assouan and Cairo, from the mean high flood levels at these stations (determined from the data of a large number of years), for each year of the period 1875-92. Column 4 gives the general character of the South-west Monsoon rainfall in India for the same period, and column 5 gives estimates of the actual variations in India (but determined from increasing data from 1875-92, and therefore not strictly comparable from year to year).

The height of the maximum flood level in the Nile probably furnishes an approximate estimate of the character of the rainfall in the basins of the Blue and White Nile, which gives rise to the Nile floods. According to the previous statement the flood level was higher than usual in nine years of increased rainfall in India, or *vice versâ*, the two thus varying directly. In nine years the relation between the two was inverse. Hence the data throw little light on the relation. Probably fuller information as to the distribution of the rainfall during the season would enable the question of how far variations of the rainfall in this area affected the seasonal rainfall in India.

The main object of the paper is to show that the Indian Monsoon charts can give much valuable information respecting the nature of the air movement over the Indian seas, and throw light on the causes of the variation of the Monsoon rainfall in India—a subject of the greatest importance from an economic standpoint.

DISCUSSION.

Mr. B. Latham said that the paper was one which it was difficult to discuss, and would doubtless repay very careful study. Those conversant with the climate of India knew how sudden a transition took place from a condition of extreme atmospheric dryness to one of high humidity, followed by heavy rainfall, and it was desirable that the cause of this remarkably abrupt change should be understood. No doubt the flow of moist air came from the equatorial belt, but it was not at all certain that the author of the paper gave the correct explanation of the cause of the breaking of the Monsoon.

Mr. R. H. Scott remarked that great credit was due to Mr. Eliot for the results now submitted from his careful study of the maps. It was to be regretted that the sea observations were comparatively very scanty, but that was unavoidable under the circumstances.

Mr. W. C. Lewis considered that Mr. Eliot's paper was a distinct advance upon the knowledge already possessed concerning Indian meteorology. The charts were most interesting: but he noticed that Mr. Eliot had omitted to call attention to the fact that almost every year the "burst of the Monsoon" was accompanied by two cyclonic storms, one forming over the Bay of Bengal, and the other in the region of Bombay. It appeared that the condensation in the Bay of Bengal started these cyclones, and disturbed the conditions of pressure all round the coast of India. The charts for April and June in Mr. Eliot's paper were especially interesting, that for April showing almost uniform pressure from the equator to Bengal, being a great contrast to the June one, which showed the conditions succeeding the "burst of the Monsoon." Mr. Eliot's paper

went a long way towards proving the case for the "burst of the Monsoon" being a dynamic phenomenon.

Captain D. Wilson-Barker said that Mr. Scott had certainly drawn attention to a weakness in the paper, when he alluded to the lack of observations over the sea. It was also to be regretted that the influence of the Himalaya Mountains appeared to have been ignored by Mr. Eliot. Regarding the "burst of the Monsoon," this was not a phenomenon peculiar to India alone, for a similar transition on a smaller scale from a dry to a moist season was known, but under other names in almost every tropical country, as, for instance, the Soudan and Australia. The paper was undoubtedly one of considerable importance, and was very welcome, as no one could better deal with the subject than an observer on the spot.

Mr. C. Harding said that he had tried to discover how far the results of Mr. Eliot's investigations confirmed or refuted the opinions put forward by the late Mr. Blanford with respect to the source or origin of the South-west Monsoon, and he had concluded that they did both. Mr. Eliot had considerable advantages over his predecessor in being able to avail himself of the use of synchronous charts, and he (Mr. Harding) was decidedly of opinion that synchronous observations afforded many opportunities for deduction not similarly obtainable from mean results, especially in the carrying out of a discussion such as was contained in this paper. Mr. Blanford had in some of his writings stated that he believed that a study of the cold weather storms of India would help to throw light upon the movement of cyclones in the region of the British Isles. A knowledge of the causes which operated to produce such storms in India was of the utmost value to the inhabitants of that country, for upon the rainfall accompanying these storms depended the success or failure of the crops which provided their means of sustenance. The paper by Mr. Eliot was of considerable importance to those engaged either on sea or on land.

Mr. H. N. Dickson said that Indian meteorologists, although possessing perhaps the best meteorological organisation in the world, laboured under the serious difficulty of having as their near neighbour a country which possessed no organisation whatever, viz. Thibet. It seemed unlikely that a complete explanation of the phenomena discussed in Mr. Eliot's paper would be obtained until simultaneous observations were made on both sides of the Himalayas. Possibly the bursting of the Monsoon might be due to the junction of the ascending currents over Central Asia and Hindostan at a great elevation, in a manner similar to that in which two cyclones coalesce at lower levels.

The Diurnal Variation of Wind-Velocity at Tokio, Japan.

By CHARLES DAVISON, M.A., F.G.S.

(Communicated by G. J. Symons, F.R.S., Secretary.)

[Read November 20, 1895.]

THE Imperial Meteorological Observatory, Tokio, was situated, till July 1882, on the upper level of the city, about a mile to the west of the northern extremity of the Gulf of Tokio; lat. 35° 39′ 50″ N., and long. 139° 45′ 10″ E. The Robinson's Anemograph (made by Casella) was on a stage situated on the brow of a hill, the commencement of which is about 80 yards to the east-south-east, and which gradually increases in height towards the south, west, and north, at which latter point it was 60 yards distant, and had an elevation of about 35 feet above the level of the thermometers. The stage was 30 feet above the base.

In July 1882 the Observatory was moved to a new position off the eastern side of a large square foundation (Tenshudai) within the castle of Tokio; lat. 35° 41′ N., long. 139° 45′ E. The anemograph was erected on a tower well exposed in all directions.

TABLE I.—Mean Velocity of Wind at Tokio, 1876-1885.
Kilometres per Hour.

Hour	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
a.m.													
0–1	9·69	10·25	10·71	10·90	9·59	7·98	9·34	8·28	8·45	9·06	9·78	9·52	9·46
1–2	9·30	10·42	10·78	10·58	9·19	7·66	8·71	7·59	8·54	9·23	9·69	9·48	9·26
2–3	9·11	10·60	10·41	10·37	9·18	7·43	8·06	7·26	8·35	9·58	9·60	9·68	9·14
3–4	9·00	10·90	10·42	10·26	8·92	7·18	8·08	7·28	8·71	9·42	9·32	9·46	9·08
4–5	9·13	10·81	10·13	10·26	8·78	7·30	8·07	7·14	8·61	9·57	9·14	9·52	9·04
5–6	8·67	10·77	9·76	9·95	8·44	7·53	7·70	6·80	8·39	9·54	9·24	9·37	8·85
6–7	8·56	10·38	9·35	10·23	8·45	7·67	8·14	7·19	8·37	9·70	9·11	9·09	8·85
7–8	8·61	10·53	9·96	10·60	9·08	8·11	9·18	7·97	9·09	9·97	9·11	8·86	9·26
8–9	8·75	11·08	11·40	11·90	10·32	9·04	10·32	9·30	10·13	10·83	9·78	9·00	10·15
9–10	10·34	12·37	12·81	13·13	11·75	9·78	11·57	10·30	10·72	11·36	10·81	9·82	11·23
10–11	11·42	13·12	13·86	14·66	13·38	11·15	13·23	12·09	11·89	11·48	11·45	11·00	12·39
11–12	11·79	13·04	13·96	16·04	14·29	12·41	14·77	13·32	11·93	11·63	11·25	11·52	13·00
p.m.													
0–1	12·10	13·33	15·53	17·29	16·05	13·73	16·44	14·62	13·17	12·11	11·64	12·18	14·02
1–2	12·28	12·94	16·04	18·14	17·05	14·60	17·29	15·68	13·72	12·17	11·36	12·07	14·44
2–3	12·36	13·36	16·17	19·02	17·73	15·23	17·97	16·25	13·93	12·00	11·23	11·78	14·75
3–4	11·75	13·39	16·37	19·36	17·80	15·42	18·22	16·80	14·13	11·47	10·78	11·49	14·75
4–5	10·25	12·27	15·75	19·14	17·44	14·69	17·60	16·54	13·18	10·30	9·30	9·67	13·84
5–6	8·91	10·45	14·22	18·11	16·24	14·21	16·90	15·41	11·87	9·30	8·48	9·18	12·77
6–7	9·06	10·14	12·52	16·20	14·48	13·13	15·02	13·41	10·85	8·84	8·72	9·24	11·80
7–8	9·38	10·33	11·98	15·12	13·32	11·90	12·87	11·80	10·07	8·22	8·70	9·45	11·09
8–9	9·49	10·29	11·58	13·33	12·08	11·10	12·25	10·89	9·76	8·36	8·86	9·61	10·63
9–10	9·47	10·64	11·26	12·13	11·01	9·85	11·24	10·10	9·16	8·16	9·16	9·38	10·13
10–11	10·02	10·65	10·88	11·40	10·64	9·37	10·62	9·37	8·78	8·49	9·46	9·96	9·97
11–12	9·79	10·06	10·61	10·70	10·14	8·48	9·80	8·54	8·58	8·93	9·56	9·73	9·58
Mean	9·97	11·32	12·35	13·67	12·30	10·62	12·22	11·01	10·42	9·99	9·79	10·00	11·15

TABLE II.—MEAN VELOCITY OF WIND AT TOKIO, 1876-1885.
MILES PER HOUR.

Hour.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
a.m.													
0-1	6·02	6·38	6·64	6·78	5·95	4·97	5·79	5·15	5·26	5·64	6·08	5·91	5·88
1-2	5·77	6·46	6·69	6·58	5·70	4·76	5·41	4·72	5·30	5·73	6·02	5·88	5·75
2-3	5·66	6·58	6·46	6·44	5·70	4·61	5·01	4·52	5·19	5·95	5·97	6·02	5·68
3-4	5·59	6·78	6·46	6·38	5·55	4·45	5·01	4·52	5·41	5·86	5·79	5·88	5·64
4-5	5·68	6·71	6·29	6·38	5·46	4·54	5·01	4·43	5·35	5·95	5·68	5·91	5·61
5-6	5·39	6·69	6·06	6·17	5·23	4·68	4·79	4·23	5·21	5·93	5·75	5·82	5·50
6-7	5·32	6·44	5·82	6·35	5·26	4·76	5·06	4·47	5·19	6·02	5·66	5·66	5·50
7-8	5·35	6·55	6·20	6·58	5·64	5·03	5·70	4·94	5·66	6·20	5·66	5·50	5·75
8-9	5·44	6·89	7·09	7·40	6·42	5·61	6·42	5·77	6·29	6·73	6·08	5·59	6·31
9-10	6·42	7·70	7·96	8·17	7·29	6·08	7·18	6·40	6·67	7·07	6·71	6·01	6·98
10-11	7·09	8·14	8·61	9·10	8·32	6·94	8·23	7·52	7·38	7·14	7·11	6·85	7·70
11-12	7·34	8·10	8·68	9·98	8·88	7·72	9·17	8·28	7·40	7·23	7·00	7·16	8·08
p.m.													
0-1	7·52	8·28	9·64	10·74	9·98	8·52	10·22	9·08	8·19	7·52	7·23	7·56	8·70
1-2	7·63	8·03	9·98	11·27	10·60	9·08	10·74	9·75	8·52	7·56	7·07	7·49	8·97
2-3	7·67	8·30	10·04	11·81	11·03	9·46	11·16	10·09	8·66	7·45	6·98	7·31	9·17
3-4	7·29	8·32	10·18	12·04	11·05	9·57	11·32	10·45	8·79	7·14	6·69	7·14	9·17
4-5	6·38	7·63	9·80	11·90	10·83	9·13	10·94	10·27	8·19	6·40	5·77	6·02	8·59
5-6	5·53	6·49	8·84	11·25	10·09	8·84	10·49	9·57	7·38	5·77	5·28	5·70	7·94
6-7	5·64	6·31	7·78	10·07	8·99	8·17	9·33	8·32	6·73	5·50	5·41	5·75	7·34
7-8	5·84	6·42	7·45	9·40	8·28	7·40	7·99	7·34	6·26	5·10	5·41	5·88	6·89
8-9	5·91	6·40	7·20	8·28	7·52	6·89	7·61	6·78	6·06	5·19	5·50	5·97	6·60
9-10	5·88	6·62	7·00	7·54	6·85	6·13	6·98	6·29	5·68	5·08	5·68	5·84	6·29
10-11	6·22	6·62	6·76	7·09	6·62	5·82	6·60	5·82	5·46	5·28	5·88	6·20	6·20
11-12	6·08	6·24	6·60	6·64	6·31	5·28	6·08	5·30	5·32	5·55	5·95	6·04	5·95
Mean	6·20	7·05	7·67	8·50	7·65	6·60	7·58	6·85	6·46	6·22	6·08	6·22	6·92

TABLE III.—HARMONIC COMPONENTS OF WIND-VELOCITY AT TOKIO, 1876-1885, IN KILOMETRES AND MILES PER HOUR.

Month.	First Component.			Second Component.			Third Component.			Fourth Component.		
	Amplitude.		Epoch	Amplitude.		Epoch	Amplitude.		Epoch	Amplitude.		Epoch
	kils.	mls.	a.m.	kils.	mls.	a.m.	kils.	mls.	a.m.	kils.	mls.	a.m.
January .	1·62	1·01	11·50	1·13	·70	0·45	·36	·22	5·20	·18	·11	3·45
February .	1·68	1·05	11·40	0·76	·47	1·10	·18	·11	5·10	·43	·27	3·45
			p.m.									
March . .	3·23	2·01	0·50	1·14	·71	1·50	·14	·09	0·55	·35	·22	3·40
April . .	4·79	2·98	1· 0	1·13	·70	3· 0	·23	·14	1·40	·03	·02	4·15
May . .	4·70	2·92	1· 0	1·15	·71	2·30	·11	·07	0·50	·18	·11	4·05
June . .	4·21	2·62	1· 0	0·70	·43	2·55	·22	·14	0·25	·01	·01	4·05
July . .	5·30	3·29	1·05	1·01	·63	2·20	·21	·13	0·05	·16	·10	4·40
August . .	4·92	3·06	1·05	0·98	·61	2·55	·10	·06	6·10	·24	·15	4·20
September .	3·06	1·90	0·35	0·79	·49	1·55	·10	·06	7·30	·26	·16	3·25
			a.m.									
October .	1·63	1·01	11·25	0·76	·47	1·25	·12	·07	7·25	·15	·09	2·55
November .	1·01	0·63	11·20	0·91	·57	0·40	·12	·07	5·10	·13	·08	3·15
December .	1·37	0·85	11·35	0·94	·58	1· 0	·46	·29	5·05	·03	·02	3·30

The hourly means of wind-velocity for each month are published in the *Report of the Meteorological Observations for the Ten Years* 1876-1885 *made at the Imperial Meteorological Observatory of Tokio.* These means in kilometres per hour are given in Table I., and in miles per hour in Table II.;

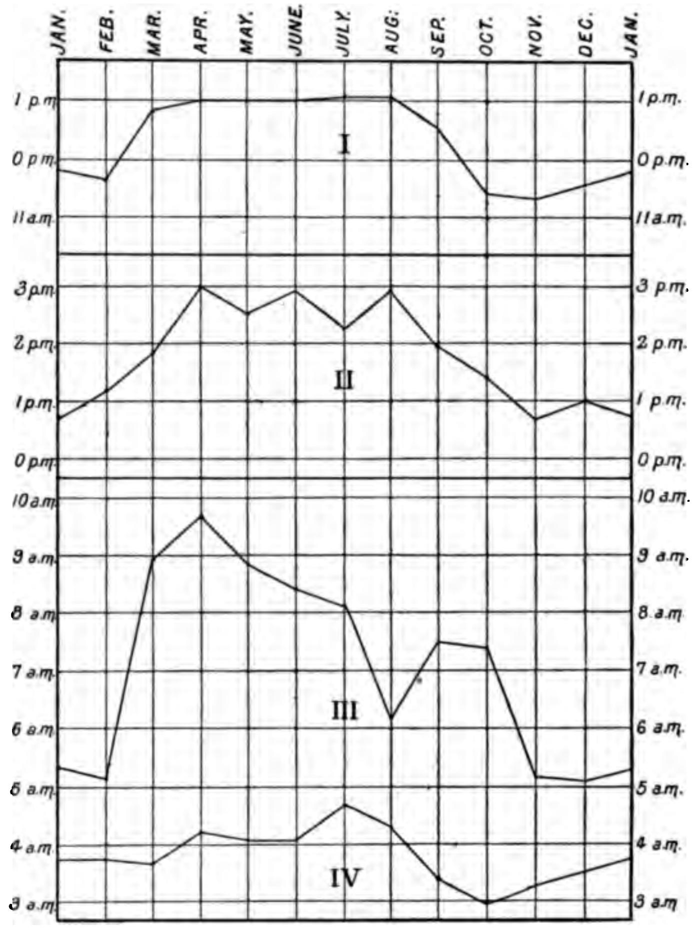

JAN.
FEB.
MAR.
APR.
MAY.
JUNE.
JULY.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
1 p.m.
0 p.m.
11 a.m.
3 p.m.
2 p.m.
1 p.m.
0 p.m.
10 a.m.
9 a.m.
8 a.m.
7 a.m.
6 a.m.
5 a.m.
4 a.m.
3 a.m.
I
II
III
IV

FIG. 1.

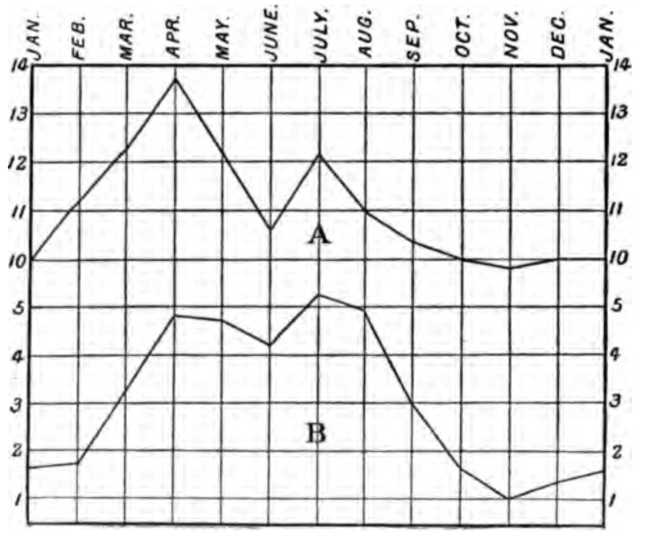

JAN.
FEB.
MAR.
APR.
MAY.
JUNE.
JULY.
AUG.
SEP.
OCT.
NOV.
DEC.
JAN.
14
13
12
11
10
5
4
3
2
1
A
B

FIG. 2.

having been previously corrected for frictional error. In Table III. are given the results of the harmonic analysis as far as the fourth component; the amplitudes are expressed in kilometres, and also in miles, per hour, and the epochs are reckoned from midnight (Tokio mean time).

An examination of Table III. shows that the diurnal component is by far the most important. Both the amplitude and the epoch are clearly subject to an annual period. The amplitude is least in November, and in the same month the epoch is earliest. The amplitude increases until April, diminishes slightly in May and June, and reaches a maximum in July, after which it decreases until November. As the amplitude increases or diminishes, the epoch generally becomes later or earlier in the day, varying between 11.20 a.m. in November and 1.5 p.m. in July and August.

The amplitudes of the other three components are extremely variable. Their epochs, however, follow roughly the same law as that of the first component. The epoch of the second component (12 hours) occurs earliest (0.40 a.m.) in November and latest (3.0 a.m.) in April. That of the fourth component (6 hours) occurs earliest (2.55 a.m.) in October and latest (4.40 a.m.) in July.

With regard to the epoch of the third component (8 hours), a difficulty occurs in the sudden leap from 5.10 a.m. in February to 0.55 a.m. in March. As General Strachey has pointed out (*Phil. Trans.* 1893A, p. 621), this is due to the monthly intervals being too long to follow such rapid changes of epoch. We cannot be certain as it is whether the epoch has advanced from 5.10 a.m. to 8.55 a.m., or retrograded to 0.55 a.m. Assuming the former to be the case, the epoch occurs earliest (5.5 a.m.) in December and latest (9.40) in April.

Fig 1 shows the changes in epoch of the first four components. In Fig. 2 the first line (A) represents the variation of mean hourly velocity, and the second line (B) that of the amplitude of the first component, throughout the year. The two curves are somewhat similar, the amplitude of the first component increasing and decreasing with the mean hourly velocity, though not in the same ratio.

Notes on some of the Differences between Fogs, as related to the Weather Systems which accompany them. Submitted to the Fog Committee.

By ROBERT H. SCOTT, M.A., F.R.S.

[Read December 18, 1895.]

In the month of June 1893 I had the honour of reading a paper before the Society on "Fogs reported with Strong Winds in these Islands," and this paper was printed in the *Quarterly Journal*, vol. xx. p. 253.

Among the peculiarities of these fogs, the circumstance was noted

that the temperature at the time the fog was reported was high in general, and frequently agreed with the maximum for the day.[1]

Moreover, the strong wind fogs were accompanied by rain, which was frequently heavy.

I have therefore endeavoured to apply a more careful test of the character of fogs with light winds in relation to maximum and minimum temperatures occurring at the time, and as to rainfall, with some information as to the distribution of pressure prevailing at the time.

A few instances of well-developed fogs were chosen, and all observations of the kind mentioned, which were taken during their prevalence, were included in the enquiry. These fogs lasted sometimes for nearly a month.

The instances selected were all historical ones, and will be in the memory of the Fellows. They are:—

1. 1873, *December* 3-15.—The great Cattle-Show fog.
2. 1879, *December* 3-27.—The period of intense cold in 1879.
3. 1880, *January* 26—*February* 6.—A fog chiefly noticeable from the great increase in the death-rate of London at its close, as is shown by the reports of the Registrar-General for the weeks ending February 7th and 14th, 1880.
4. 1881, *January* 5—*February* 4.—The period of intense cold in 1881. Towards the end of this interval the weather became cyclonic in type.
5. 1888, *January* 9-14.—A remarkable warm anticyclone. A photograph of this fog at Malvern on January 12th hangs in the rooms of the Society.

It will be sufficient to repeat that these are all well-marked instances of protracted and general fogs. In several cases fog was reported at 8 a.m. from 10 or 12 stations, and on January 10th, 1888, from as many as 15.

In each case, for the fogs reported at 8 a.m., there have been extracted:—

a. The weather reported at 8 a.m.
b. The temperature reported at 8 a.m.
c. The minimum temperature of the *preceding* 24 hours.
d. The maximum temperature of the *succeeding* 24 hours.
e. The rain for both preceding and succeeding days.

In the case of the fogs reported at 6 p.m., the temperature at the time of observation was extracted, but the maximum and minimum given in the tables refer to the same 24 hours, viz. those recorded at 8 a.m. next day. Of rain only one observation was entered.

The fogs reported with strong winds have been treated in a precisely similar manner.

The tables so prepared give the following results:—

[1] An attempt to explain away this relation was made by one of the Fellows in the discussion by suggesting that "when fog prevailed the temperature was steady and no daily range was apparent."

TABLE I.—ANTICYCLONES, 8 A.M.

DECEMBER 1873.

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
				°	°	°	in.	in.
3	Kingstown	o f	SSE_1	46	47	52	...	...
	Scilly	o f p	SSW_2	48	48	53	·01	·01
	Plymouth	f	NW_1	46	48	50	·01	...
	Dover	o f	SW_1	47	49	52	·02	...
4	Dover	b g f	WSW_1	40	43	46	...	...
	Yarmouth	c f	W_2	37	38	43	...	...
5	Plymouth	g f	E_1	41	44	49	...	...
	Dover	f g	SW_3	41	43	46	...	...
	Yarmouth	f m	W_3	36	41	47	...	...
6	Kingstown	g f	W_2	42	42	50	...	...
	Liverpool	o f	NNE_1	40	41	45	...	...
	Plymouth	g f	Z	44	45	51	...	...
	Dover	f u	NE_4	40	45	47	...	...
7	Kingstown	f g	S_2	42	49	51	...	...
	London	o f c	SW_2	36	42	47	...	...
8	York	c f	SSW_1	38	41	48	...	·01
	Plymouth	f m	NE_1	41	43	49	...	...
9	Plymouth	b f	Z	31	33	47	...	...
	London	o b f	Z	24	24	39	...	...
	Yarmouth	c f	WSW_2	34	35	43	...	...
10	Nottingham	m f	W_1	25	27	38	...	...
	Kingstown	m f	Z	39	40	45	...	...
	Roche's Point	b f	WNW_2	36	39	48	...	...
	Portishead	m f	Z	21	23	35	...	...
	Plymouth	b f	Z	28	30	45	...	...
	Dover	b f g	NNE_2	31	36	44	...	...
	London	f	Z	19	20	30	...	...
	Oxford	o f	Z	20	20	28	...	...
	Yarmouth	f m	W_2	32	39	43	...	...
11	Shields	w f	N_1	37	38	42	...	...
	York	b f	Z	26	38	38	...	...
	Nottingham	f	W_1	23	24	31	...	...
	Kingstown	f	S_1	36	39	43	...	...
	Liverpool	c f	SE_2	30	31	39	...	...
	Portishead	f	E_1	20	22	32	...	...
	Plymouth	f	E_1	30	33	44	...	...
	Dover	c f	NNE_3	35	41	44	...	...
	London	f	Z	19	25	34	...	...
	Oxford	f	Z	20	20	27	...	...
	Yarmouth	c f	W_1	33	39	42	...	·01
12	York	f	N_1	21	22	33	...	...
	Nottingham	f	S_1	20	24	27	...	...
	Kingstown	b f	S_1	36	40	45	...	...
	Holyhead	b f	SW_1	34	34	45	...	...
	Liverpool	b f	SE_2	26	26	39	...	...
	Portishead	f	Z	21	27	38	...	·02
	Plymouth	f	Z	31	35	43	...	...
	Dover	f c	N_3	39	43	46	...	...
	London	o f	Z	25	33	38	...	...
	Oxford	f	Z	20	20	33	...	...
	Yarmouth	f	NW_4	30	31	37	·01	...
13	York	f m	SE_1	20	32	39	...	...
	Scarborough	b f	SW_2	31	36	41	...	...
	Nottingham	f	W_1	21	25	32	...	...
	Kingstown	f	Z	39	43	46	...	...

TABLE I.—ANTICYCLONES, 8 A.M.—*Continued.*

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
				°	°	°	in.	in.
	Pembroke	f m	NNE_2	34	39	43	...	·01
	Portishead	f m	Z	25	37	39	·02	...
	Plymouth	f	NE_1	35	42	48	...	...
	Dover	o f	NNW_2	39	40	42	...	...
	London	o f	W_1	31	35	39	...	...
	Oxford	f	Z	20	33	35	...	·03
	Cambridge	b f c	SW_1	22	32	35	...	...
	Yarmouth	f	W_2	27	29	36	...	...
14	York	f o	W_1	28	38	41	...	...
	Scarborough	f o	SW_2	36	39	42	...	...
	Nottingham	f	WSW_1	25	32	35	...	...
	Kingstown	f m	SSE_1	41	43	51	...	...
	Holyhead	m f	SSW_2	42	44	50	...	·03
	Pembroke	f m	SE_2	38	43	49	·01	...
	Dover	f	NNW_2	35	37	41	...	...
	London	f o m	NW_1	33	34	39	...	·03
	Yarmouth	f	WSW_1	27	34	37	...	·02
15	Scarborough	f c	SW_3	30	34	55	...	...
	Dover	f o	SW_3	36	40	50	...	·08
	Yarmouth	f g	SSW_2	32	36	54	·02	·03
	December 1879.							
3	Nottingham	f	Z	5	16	24	...	...
	Ardrossan	b f	ENE_1	21	22	30	...	...
	London	f g	NE_1	14	23	32	...	...
	Dover	b f	Z	27	28	34	...	...
4	Ardrossan	b f	E_2	15	17	37	...	·03
6	Shields	f	W_1	26	28	33	·35*	...
	York	f	WNW_1	11	12	25	·21	...
	London	b f	NW_1	24	29	34	·03	...
7	Kingstown	b c f	Z	26	28	36	...	...
	London	b f	Z	13	15	35	...	...
	Oxford	b f	NNE_1	12	12	35	...	...
8	Kingstown	b f	W_1	26	29	37	...	...
	Holyhead	f	SW_1	34	34	42	...	...
	Roche's Point	f	NNE_3	30	31	39	...	...
9	Kingstown	o f	WNW_1	26	33	45	...	·05
	Roche's Point	f	N_2	31	38	42	...	...
	Oxford	f	Z	20	21	35	...	·03
10	Holyhead	f	WSW_1	40	42	45	·02	...
	Oxford	o f	W_1	20	35	36	·03	...
11	Spurn	f	WSW_4	27	29	37	...	...
	York	f	SE_1	14	17	27	...	...
	Nottingham	o f	Z	19	20	31	·05	...
	Kingstown	o f	Z	30	33	43	...	·01
	Liverpool	f	SE_1	29	32	39	...	...
	London	b f	Z	19	22	34	...	...
	Oxford	o f	Z	19	20	32	...	...
12	Dover	o f	NNW_2	31	34	38	...	·03
	London	o g f	NW_1	19	32	39	...	...
	Yarmouth	f	WNW_2	24	32	36	...	·03
13	Dover	o f d	NNE_2	34	36	38	·03	·01
	London	o g f	SW_1	32	34	39	...	...
	Yarmouth	f	Z	30	34	35	·03	...

* The precipitation was snow from the NW. wind of a depression which had passed on the 5th.

TABLE I.—ANTICYCLONES, 8 A.M.—*Continued.*

DECEMBER 1879.

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
				°	°	°	in.	in.
14	Yarmouth . . .	b c f	WSW_2	30	32	37	...	·02
15	Nottingham . .	f	Z	35	38	43	...	...
	Yarmouth . . .	f	W_2	31	37	38	·02	...
16	York	f	SSW_1	35	36	40	...	...
	Oxford . . .	o f	Z	35	36	37	·01	...
	Yarmouth . . .	f	Z	30	32	37	...	...
	Spurn . . .	f	SE_4	36	38	40	...	·01
17	Wick	f	SW_1	37	39	45	...	...
	Shields . . .	f	WSW_1	32	35	46	...	...
	York	f	S_1	30	31	37	·01	...
	Nottingham . .	o f	SW_1	30	30	38	...	...
	Hurst Castle . .	f	NNE_2	22	27	35	...	...
	London . . .	o f	NW_1	23	23	34	...	...
	Oxford . . .	o f	Z	23	23	30	...	...
	Yarmouth . . .	f	Z	22	22	37	...	·02
18	Spurn . . .	f	N_2	31	39	42	...	·01
	Kingstown . . .	c f	S_1	32	34	42	...	·01
	Liverpool . . .	f	Z	33	36	38	...	...
	Hurst Castle . .	f	ENE_3	25	31	38	...	...
	London . . .	o f g	Z	22	34	40	...	...
	Oxford . . .	o f	Z	23	30	37	...	...
	Cambridge . . .	f	Z	23	32	37	...	...
19	Wick	f	Z	29	36	43	...	...
	Kingstown . . .	c f	W_1	30	33	41	·01	·02
	Holyhead . . .	f	S_1	31	32	39	...	...
	London . . .	b f	NE_2	31	32	37	...	...
20	Ardrossan . . .	c f	E_3	30	31	38	...	...
21	Hurst Castle . .	f	ESE_4	30	31	43	...	·02
	Yarmouth . . .	b c f	Z	27	30	36	...	...
22	Yarmouth . . .	f	SW_2	26	36	39	...	...
23	Dover . . .	o f	WSW_2	34	37	38	...	...
	London . . .	f	Z	28	32	37	...	...
	Oxford . . .	o f	Z	23	28	37	...	...
24	Hurst Castle . .	f	Z	27	27	42	...	·02
	London . . .	b c f	SW_1	23	23	40	...	...
	Yarmouth . . .	b f	SW_2	27	30	34	...	...
25	Nottingham . .	f	Z	26	27	30	...	...
	Pembroke . . .	f o	ENE_1	33	35	44	·03	...
	Hurst Castle . .	f	E_1	27	39	41	·02	...
	Dover . . .	o f	N_2	34	38	39	...	·02
	London . . .	f	Z	33	34	35	...	...
	Oxford . . .	o f	Z	30	30	34	·01	...
	Cambridge . . .	f	S_1	25	26	40	...	...
	Yarmouth . . .	f	W_2	27	28	35	...	...
26	Spurn . . .	f	SE_5	27	28	33	...	...
	York	f	SE_1	21	28	32	...	...
	Dover . . .	o f	SE_2	31	33	33	·02	...
	London . . .	g f	SE_1	29	30	35	...	...
	Oxford . . .	o f	S_1	29	34	34	·01	...
27	Dover . . .	o f	SW_3	26	32	41	...	·01

TABLE I.—Anticyclones, 8 A.M.—*Continued.*

January and February 1880.

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
				°	°	°	in.	in.
26	Holyhead . . .	o f	SSW_2	33	34	37	...	...
	London . . .	f	Z	18	19	34	...	...
	Oxford . . .	b c f	Z	21	21	34	...	.
27	Nottingham . .	f	SSW_1	19	22	29	...	...
	Dover . . .	b f	NE_1	25	26	35	...	...
	London . . .	f	Z	17	20	34	...	...
	Oxford . . .	o f	Z	16	18	29	...	...
	Yarmouth . . .	f	Z	26	29	35	...	...
28	York	f	S_1	21	23	33	...	...
	Nottingham . .	o f	SSW_2	22	24	29	...	...
	Hurst Castle . .	f	ENE_1	23	27	33	...	...
	Dover . . .	b f	N_1	24	25	34	...	...
	London . . .	f	SSE_1	16	22	26	...	...
	Oxford . . .	o f	Z	18	19	25	...	...
	Cambridge . . .	f	S_1	16	19	29	...	...
	Yarmouth . . .	f	SW_1	20	24	28	...	...
29	Hurst Castle . .	f	ENE_1	26	29	40	...	·05
	Oxford . . .	o f	Z	18	23	34	...	...
	Yarmouth . . .	f	Z	17	23	34	...	·02
30	Yarmouth . . .	b f	SSW_2	22	34	40	·02	..
31	Holyhead . . .	f	SSW_3	40	46	48	·02	·01
	Dover . . .	b f	Z	33	34	44	...	...
	London . . .	f	Z	28	31	55	...	...
	Oxford . . .	b f	W_1	33	35	49	...	...
	Yarmouth . . .	b f	SSW_2	33	36	42	...	...
Feb.								
1	York	f	S_1	31	31	48	...	...
	Nottingham . .	f	Z	27	28	46	...	...
	London . . .	f	Z	27	29	48	...	...
	Oxford . . .	o f	Z	26	26	50	...	...
	Yarmouth . . .	b f	WSW_2	33	35	45	...	...
2	Liverpool . . .	o d f	WSW_1	48	49	50	·37	...
	Dover . . .	o f	WSW_2	31	35	41	...	·02
	London . . .	f	Z	27	28	50	...	...
	Yarmouth . . .	b f	WSW_1	33	36	42	...	...
3	York	f	S_1	34	42	50	...	...
	Nottingham . .	f	S_1	32	41	46	...	·02
	Pembroke . . .	o f	S_1	43	44	46	·04	·10
	Scilly	f	SW_2	45	45	51	·05	·06
	Prawle Point . .	f	SSW_2	43	46	43	·05	·11
	Dover . . .	o f	WSW_2	34	36	39	·02	...
	Yarmouth . . .	f	WSW_1	35	38	42	...	...
4	Spurn . . .	f	S_3	38	40	44	...	...
	Hurst Castle . .	f	E_2	33	34	39	·01	·01
	Dover . . .	b f	SW_1	32	35	41	...	...
	London . . .	b f	SW_1	30	31	54	...	...
	Oxford . . .	o f	Z	39	40	47	·08	·01
	Yarmouth . . .	f	Z	31	33	42	...	...
5	Hurst Castle . .	f	SE_2	33	37	45	·01	·03
	Dover . . .	o f	W_3	32	36	41	...	·02
	London . . .	f	W_2	25	28	54	...	·02
	Oxford . . .	o f	Z	30	32	46	·01	·01
	Yarmouth . . .	b f	SSW_1	31	33	44	...	·03
6	Spurn Head . .	f	SSE_4	34	38	46	·04	·01
	Oxford . . .	o f	Z	32	43	49	·01	·06
	Yarmouth . . .	f	SSW_2	31	40	44	·03	·11

TABLE I.—ANTICYCLONES, 8 A.M.—*Continued.*
JANUARY 1881.

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
				°	°	°	in.	in.
5	Stornoway	f	Z	28	30	36	...	...
	Leith	f	Z	27	28	35	·01	...
	Ardrossan *	f	NE_2	29	29	42	...	...
8	Ardrossan	c f	ENE_3	25	27	29	...	...
	Yarmouth	b c f	N_1	35	37	40	...	...
	Nairn	f	Z	18	20	29	...	...
9	Nairn	f	Z	20	21	33	...	·03
	Ardrossan	o f	NE_1	25	27	33	...	...
10	Ardrossan	o f	Z	24	25	33	...	...
11	Ardrossan	c f	SSE_1	23	26	34	...	...
	London	f g s	N_1	32	32	36	...	·10
14	Ardrossan	b c f	Z	19	20	31	...	...
	York	f	N_1	18	20	21	...	...
	Nottingham	f	N_1	12	19	22	·01	...
	Oxford	b f	NNW_1	11	12	30	...	...
15	York	f	NE_1	3	7	18	...	·02
	Ardrossan	b f	ESE_1	18	22	32	...	...
	Parsonstown	f	S_1	16	20	24	...	...
	Barrow †	f	NE_2	19	23	27	...	·08
	London	f	W_1	11	12	26	...	...
	Oxford	b f	SW_1	9	10	26	...	...
16	Ardrossan	b c f	ESE_2	15	17	29	...	...
	Pembroke ‡	f	ENE_1	24	30	38	·07	...
	London	b f	W_1	11	14	29	...	...
17	Leith	b f	W_1	9	12	32	...	...
	Spurn Head	f	WSW_3	20	20	25	...	...
	York	f	Z	8	10	29	·01	...
	Ardrossan	b f	ENE_1	5	17	29	...	...
	London	b f	Z	9	10	32	...	...
	Oxford	b f	Z	10	10	31	...	...
20	Leith	c f	W_1	20	23	31	·04	·14
21	Ardrossan	o f	NE_2	22	27	29	...	...
	London	b f	ENE_1	12	21	31	...	...
22	Ardrossan	b f	E_1	12	18	38	...	·04
	Oxford	f	N_1	7	9	31	...	...
	Yarmouth §	f g	W_3	15	26	34	·07	·09
24	Leith	b f	W_1	12	22	34	...	...
	Spurn Head	f	NW_2	20	22	25	...	...
	York	f	Z	15	25	27	...	...
	Nottingham	o f	Z	16	22	26	...	...
	Ardrossan	o f	NE_1	12	26	37	...	...
	Holyhead	f	SSW_2	30	32	36	...	·02
	Hurst Castle	f	E_1	20	22	30	...	...
	Dover	o f	NNE_1	26	29	32	...	...
	London	f	Z	24	24	29	...	...
	Oxford	f	Z	11	18	23	...	...
	Cambridge	f	Z	18	19	24	·02	...
25	Spurn Head	f	SSW_1	14	14	24	...	...
	York	f	S_1	17	17	18	...	...
	Nottingham	o f	SSW_1	11	11	19	...	...
	Barrow	f	ENE_3	18	18	30	...	...
	Holyhead	f	SSW_1	31	33	38	·02	...
	Oxford	o f	Z	16	20	22	...	...

* "b" at 2 p.m.
† Rain in small local depression over Irish Sea.
‡ Rain due to local depression.
§ ? Cyclonic over North Sea.

TABLE I.—ANTICYCLONES, 8 A.M.—*Continued.*

JANUARY 1888.

Date.	Station.	Weather reported at time.	Wind.	Temperatures.			Rain.	
				Minimum recorded at time.	At time of observation.	Maximum recorded next morning.	Recorded at time of observation.	Recorded next morning.
				°	°	°	in.	in.
9	Loughborough	f w	SW_1	36	36	54	...	...
	Barrow	f	SW_1	42	43	46	·01	·03
	Liverpool	b f	SSE_1	41	41	53	...	·02
	Roche's Point	f	S_2	46	46	50	·06	·01
	Pembroke	f	SSE_2	46	46	46	·03	·02
	Scilly	f	SSE_1	45	48	50	·01	·03
	Prawle Point	f	NW_2	43	45	49	·04	·01
	Jersey	f	NNW_2	45	47	49	·05	·01
	Hurst Castle	o f	NNW_2	43	45	46	...	·02
	Oxford	f	SW_3	42	42	46	...	...
10	Shields	f w	Z	37	38	48	...	...
	York	f	S_1	34	35	43	...	·01
	Loughborough	f	Z	33	34	49	...	...
	Donaghadee	f	S_3	43	46	48	·01	...
	Barrow	o f	ENE_3	38	40	45	·03	·03
	Holyhead	f	SSW_1	43	44	45	·01	·01
	Roche's Point	f	SSW_3	46	46	49	·01	·01
	Pembroke	f	SSE_3	40	44	44	·02	·02
	Scilly	o f	SSE_3	45	47	48	·03	·01
	Jersey	f	SE_3	43	44	45	·01	·01
	Hurst Castle	f	E_1	38	40	45	·02	·02
	Dungeness	f	NW_1	36	37	41	·02	·02
	London	o f	W_1	34	35	46	...	·01
	Oxford	f	Z	32	33	41	...	...
	Yarmouth	b f	WNW_2	40	41	51	...	·01
11	Spurn Head	f	Z	38	38	41	...	·01
	York	f	SE_1	31	33	39	·01	·02
	Loughborough	f	SW_1	29	30	32	...	...
	Donaghadee	f	SSW_3	42	44	46	...	...
	Barrow	f	SW_2	38	39	40	·03	·02
	Liverpool	f	WNW_1	38	39	39	·02	...
	Roche's Point	f	S_4	44	45	47	·01	...
	Prawle Point	f	E_3	40	43	44	...	...
	Jersey	f	E_2	40	41	41	·01	·01
	Hurst Castle	f	E_1	34	36	42	·02	·02
	Dungeness	f	Z	35	35	40	·02	·02
	London	f	Z	32	33	40	·01	·01
	Oxford	f	Z	30	30	34	...	...
	Yarmouth	b f	W_1	34	38	42	·01	·02
12	Aberdeen	f	SSE_2	30	33	37	·01	...
	Leith	f	W_1	32	34	41	...	...
	Shields	f	S_1	30	30	37	...	...
	Spurn Head	f	SSE_1	35	35	37	·01	·01
	York	f	S_1	32	32	34	·02	·01
	Ardrossan	o f	Z	34	37	43	...	...
	Barrow	f	ENE_2	31	32	35	·02	...
	Liverpool	f	ESE_1	30	30	38	...	·01
	Prawle Point	f	ENE_3	37	42	44	...	...
	Jersey	f	ENE_1	36	36	43	·01	...
	Dungeness	f	NE_1	34	40	41	·02	...
	London	f	Z	34	35	38	·01	...
	Oxford	f	Z	30	30	33	...	·02
	Yarmouth	b c f	Z	36	38	39	·02	·03

TABLE I.—ANTICYCLONES, 8 A.M.—*Continued.*

JANUARY 1888.

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
				°	°	°	in.	in.
13	Sumburgh Head	r f	W_1	39	45	46	·02	·02
	Wick	f	Z	30	41	46	·02	·02
	Spurn Head	f	S_2	32	32	40	·01	...
	York	f	NNE_1	28	29	42	·01	·03
	Loughborough	o f	ESE_1	28	29	35	·01	·01
	Ardrossan	o f	Z	35	43	43	...	...
	Pembroke	f	E_2	33	33	38	...	...
	Scilly	o f	E_4	43	45	45	...	...
	Prawle Point	f	ENE_4	38	40	40	...	...
	Oxford	f	S_1	30	31	32	·02	...
	Yarmouth	f	SSE_1	35	37	38	·03	...
14	Wick	f	S_1	40	41	41	·02	...
	Aberdeen	f	Z	30	37	41	·03	...
	Malin Head	o f	SSE_3	38	38	41	...	...
	Barrow	f	NW_1	34	38	41	...	...
	Liverpool	f	SSE_1	34	36	41	·02	...
	Prawle Point	f	N_3	29	32	42	...	...
	London	o g f	E_1	31	32	36	...	...
	Oxford	o f g	SW_1	28	31	35	...	·01
	Yarmouth	f	Z	31	33	38	...	...
	FOGS WITH STRONG WINDS, 8 A.M.							
1876.								
Jan. 29	Valencia	f	SSW_6	40	49	51	·03	·93
30	Pembroke	f	S_6	43	48	49	·09	·09
Feb. 17	Pembroke	f	SW_7	45	49	50	·40	·16
Mar. 3	Pembroke	o f	SW_6	44	49	50	·12	·02
Sept. 26	Scilly	o f d	WSW_6	55	58	59	·27	·01
Nov. 15	Wick	f	SE_6	40	50	51	·81	...
Dec. 29	Roche's Point	r f	S_6	46	50	52	·18	1·26
1877.								
Jan. 6	Roche's Point	r f	SE_6	40	48	51	·22	·75
16	Scilly	f	SSW_6	47	52	54	·07	·15
23	Roche's Point	r f	S_6	47	50	51	·12	·45
May 17	Scilly	o d f	WSW_6	51	54	56	·74	...
19	Sumburgh Head	f	ENE_6	42	46	48	·11	·01
19	Stornoway	d f	NNE_6	45	47	52	·12	·02
June 2	Pembroke	r f	SSW_7	50	52	55	·46	·03
2	Scilly	d o f	SW_7	50	55	59	·04	·01
12	Scilly	o f	NE_6	54	56	59	·27	·01
July 19	Scilly	f d	W_6	57	60	63	·19	·04
Aug. 14	Sumburgh Head	f	NE_6	50	52	56	...	·01
15	Sumburgh Head	f	NE_6	51	55	59	·01	...
27	Pembroke	o f r	SW_6	57	61	63	·49	·20
Oct. 30	Roche's Point	r f	SSW_6	50	55	59	·11	·15
Nov. 21	Pembroke	r f	W_6	46	53	54	·28	·21
Dec. 28	Roche's Point	r f	S_6	35	47	53	·25	·40
1878.								
Jan. 20	Scilly	f	SW_6	48	51	53	·05	·02
22	Pembroke	o f	WSW_6	50	51	52	·12	·03
Feb. 15	Scilly	f d	SSW_6	45	52	53	·09	·05
16	Scilly	o f	S_6	49	50	53	·05	·04
28	Scilly	f d	SW_6	50	53	54	·16	·11

TABLE I.—Fogs with Strong Winds, 8 A.M.—*Continued.*

Date.	Station.	Weather reported at time.	Wind.	Temperatures.			Rain.	
				Minimum recorded at time.	At time of observation.	Maximum recorded next morning.	Recorded at time of observation.	Recorded next morning.
				°	°	°	in.	in.
April 13	Scilly . .	f d	S_6	48	52	56	·86	·02
Nov. 28	Dover . .	o u d f	NNE_6	40	46	47	·11	·64
Dec. 30	Dover . .	o f r	WSW_6	43	49	50	·08	·23
1879.								
Jan. 13	Scilly . .	f d	WSW_6	42	51	53	·12	·25
Feb. 9	Pembroke . .	f	SSW_6	44	47	47	·58	·03
10	Scilly . .	o d f	SSE_6	49	50	52	·24	·11
Mar. 25	Dover . .	o f s	E_6	31	33	39	·02	·04
April 7	Wick . .	f	S_6	40	42	43	·01	·35
10	Scilly . .	o f	NNE_6	45	46	46	·01	·03
May 30	Sumburgh Head	f	NE_6	44	49	53	...	...
June 19	Scilly . .	o f	S_6	54	57	59	·03	·22
July 7	Scilly . .	f d	WSW_6	54	57	61	·13	·02
20	Pembroke . .	f	WSW_7	54	56	58	·34	·06
20	Prawle Point .	f	SW_7	54	56	60	·48	...
31	Pembroke . .	o f	SSE_6	54	58	60	·19	·08
31	Scilly . .	o f p	SSW_6	56	60	64	·20	·08
Aug. 20	Scilly . .	f d	SSW_6	57	62	65	·42	·16
Sept. 2	Ardrossan . .	r f	SSW_6	52	53	57	·28	·29
7	Wick . .	f	SE_6	52	53	55	·03	·01
Oct. 22	Scilly . .	o f	W_6	53	56	57	·02	·01
Dec. 28	Pembroke . .	o f	SW_6	50	53	54	·11	·08
1880.								
Mar. 5	Pembroke . .	c f	WSW_6	45	48	49	·02	·01
16	Scilly . .	r f	ESE_6	47	48	49	·01	·16
17	Scilly . .	r f	E_6	47	49	50	·16	·37
Dec. 22	Pembroke . .	r f	WSW_6	46	52	52	·34	·20
1881.								
Jan. 19	Pembroke . .	b c f	NNE_6	27	28	33	...	·05
Feb. 14	Pembroke . .	r f	ESE_6	41	43	46	·36	·35
Mar. 10	Scilly . .	o f	WSW_6	49	50	51	·01	·02
May 6	Pembroke . .	f	SW_6	48	50	51	·01	...
Aug. 3	Holyhead . .	f q	SSW_6	55	59	62	·06	...
Dec. 24	Ardrossan . .	o f	S_6	30	44	47	...	·62
1882.								
Jan. 5	Valencia . .	f g	WSW_6	42	53	55	·49	·10
6	Ardrossan . .	b f	WSW_8	43	44	46	·43	·21
Mar. 10	Scilly . .	f	SW_6	50	52	54	·02	·03
April 22	Roche's Point .	r f	SE_6	48	51	55	·24	·25
Aug. 6	Stornoway . .	f	WSW_6	54	58	58	...	...
1883.								
May 12	Holyhead . .	f q	SSW_6	44	50	54	·17	·07
13	Holyhead . .	r f q	SSW_6	43	50	55	·07	...
Aug. 9	Liverpool . .	f	WSW_6	53	55	62	·47	...
Oct. 7	Sumburgh Head	f	W_6	41	53	64	·39	...
1884.								
Jan. 23	Pembroke . .	f	SSW_7	49	50	51	·22	·26
23	Prawle Point .	f	SW_6	47	50	51	·23	·08
23	Hurst Castle .	o d f	SW_8	46	49	53	·06	·18
Aug. 6	Wick . . .	f	S_6	54	56	62	...	...
1885.								
Nov. 29	Pembroke . .	r f	SSW_6	45	53	54	·38	·25
1886.								
Mar. 27	Pembroke . .	f	SSW_7	45	46	48	·60	·22

TABLE I.—FOGS WITH STRONG WINDS, 8 A.M.—*Continued.*

DATE.	STATION.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
				°	°	°	in.	in.
April 20	Yarmouth	f g	ENE_7	40	42	47	...	·01
1887.								
Jan. 11	Pembroke	f	SSE_7	40	48	49	·40	·17
Mar. 4	Scilly	o f	E_6	41	44	45	...	...
1888.								
Jan. 8	Dungeness	f	W_6	44	45	47	...	·01
Jan. 22	Scilly	o f	WNW_6	48	49	49	·16	·01
Mar. 8	Holyhead	o f q	SSW_6	43	45	47	·05	·20
8	Prawle Point	f	SSW_6	37	46	48	·12	·20
Mar. 10	Hurst Castle	f	SW_7	43	43	47	·25	·51
Nov 15	Pembroke	r f q	SSW_6	51	54	55	·53	·05
15	Prawle Point	r f	SSW_6	51	55	56	·08	·07
Nov. 16	Pembroke	c f q	SSW_6	53	55	55	·05	·02
16	Prawle Point	f	SSW_6	54	55	55	·07	·02
1889.								
Feb. 1	Scilly	f	WSW_6	48	52	52	·04	·12
1	Hurst Castle		WSW_6	46	47	49	·01	·09
1	Holyhead	q f	SSW_6	48	49	52	·02	·02
Mar. 24	Hurst Castle	o f d	WSW_6	42	45	50	·02	·03
Aug. 3	Holyhead	f g	SW_6	56	59	63	·60	...
3	Prawle Point	f u	SSW_6	58	60	60	·23	·15
1890.								
Jan. 13	Pembroke	r f	SSW_6	46	50	50	·05	·03
April 7	Dungeness	f	W_6	45	46	54	·01	·07
June 5	Hurst Castle	f d	WSW_6	53	55	59	·97	·04
30	Hurst Castle	r f	SSW_7	53	56	63	·31	·18

Taking first the temperatures, the number of instances was noted in which the difference between the temperature, corresponding to the entry of fog, which is hereafter called the "Fog Temperature" (and which in the cases first considered is at 8 a.m.), and the maximum and minimum temperatures (as above defined) respectively, amounted to 0°, 1°, 2°, and so on. These are reproduced in Table II.

It was at once apparent that the regular anticyclonic fog does not completely annul diurnal range, but that the strong wind fog has a decided tendency to do so. The diagrams submitted herewith (not reproduced here) show very clearly the relation of the fog temperature to the respective extremes of temperature. The curves in those diagrams indicate frequency of occurrence of equal amounts of difference. Difference of 0°, or absolute agreement of fog temperature with either extreme, is shown on the left of the diagram.

It will be seen that in the anticyclonic fogs the difference between the fog temperature and the minimum is much less than that between the same temperature and the maximum. The former curve reaches its greatest frequency at differences of 2° or 3°, while the latter curve reaches its greatest frequency at differences of 4° or 5°, or even more.

In the "strong wind" fogs this relation is reversed, for in their case the curve of difference from the maximum shows its greatest frequency

at only 1°, while that of difference from the minimum shows its greatest frequency at 3°.

It is assumed that the minima dealt with are those of the night preceding the foggy morning. The cases in which the minimum temperature does not really belong to the night are rare, and occur with sudden changes of wind at the appearance of disturbed weather.

TABLE II.—Number of Cases of Differences between 8 a.m. Temperatures and Minimum and Maximum respectively.

Amount of Difference.	1873.		1879.		1880.		1881.		1888.		Strong Winds.	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
0°	8	1	9	2	4	0	9	0	19	8	1	10
1	14	...	20	7	13	1	9	2	21	11	18	27
2	13	6	15	4	11	3	13	4	16	9	19	21
3	7	12	14	4	12	2	5	4	8	9	20	10
4	10	7	3	8	6	5	5	5	3	10	14	16
5	7	10	4	11	1	4	6	5	1	7	7	5
6	4	7	3	5	3	9	3	2	2	3	3	3
7	5	6	5	9	...	2	2	1	1	5	3	2
8	1	7	2	11	1	3	...	7	1	4	3	1
9	...	2	2	3	2	3	1	2	...	...	3	...
10	2	3	1	2	...	4	2	3	...	3	1	...
11	...	5	1	3	1	5	1	2	1	1	1	1
12	3	1	2	5	1	...	1	5	...	1	2	...
13	1	2	...	1	...	1	...	1	...	...	...	...
14	...	1	...	1	...	3	1	1	...	...	1	...
15	...	3	1	2	...	1	...	1	...	1	...	...
16	...	...	...	...	...	1	...	1	...	...	...	...
17	...	...	...	1	...	1	...	...	...	...	...	...
18	...	1	...	...	...	1	...	1	...	1	...	...
19	...	1	...	...	...	1	...	1	...	...	...	...
20	...	...	...	2	...	...	...	2	...	...	...	...
21	...	...	...	...	...	...	...	1	...	...	...	...
22	...	...	...	...	...	1	...	2	...	...	...	...
23	...	...	...	1	...	1	...	...	...	...	...	...
24	...	...	...	...	...	2	...	...	...	...	...	...
25	...	...	...	...	...	...	...	...	...	...	...	...
26	...	...	...	...	...	1	...	...	...	...	...	...

The close approximation between the 8 a.m. fog temperature and the minimum of the preceding day is to be expected, as in winter the temperature at 8 a.m. has hardly begun to show the effects of diurnal range, by recovering from the minimum of the night. The fact that the maximum of the day shows an increase on the 8 a.m. fog temperature, indicates clearly that the sun's heat makes itself felt, and that anticyclonic fogs do not, as a rule, obliterate diurnal range.

Another interesting contrast between the anticyclonic fogs and those reported with strong winds is given by the difference in the actual temperature which accompanies them.

Taking the average of all the reports of fogs under review, we find that the 8 a.m. temperature was:—In 1873, 35°·7; 1879, 30°·0; 1880, 31°·8; 1881, 20°·8; 1888, 37°·8.

In effecting a comparison with the strong wind fogs those instances alone have been extracted which occurred in the three winter months,

TABLE III.—CYCLONIC, 8 A.M.

JANUARY AND FEBRUARY 1881.

DATE.	STATION.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
Jan.				°	°	°	in.	in.
12	Ardrossan . . .	c f	ENE_1	24	27	33	·09	·09
	Yarmouth . . .	f g	WSW_1	25	30	32	·22	·22
18	Ardrossan . . .	c f	E_3	15	29	33	...	...
26	Leith . . .	f	W_1	11	17	33	...	·02
	Spurn Head . .	f	NW_3	13	22	35	...	·01
	York	f	Z	13	15	33	...	·08
	Ardrossan . . .	f	E_1	26	27	31	...	·02
	Barrow . . .	f	E_4	15	16	32	...	·09
	London . . .	o f g	Z	17	20	38	...	·15
	Oxford . . .	o f	NE_1	18	18	36	...	·16
	Cambridge . . .	f	Z	13	14	35	...	·01
27	Spurn Head . .	f	SSE_4	21	33	35	·01	·04
	York	f	Z	15	33	35	·08	·05
	Nottingham . .	o f	Z	17	32	39	·08	·04
	Ardrossan . . .	o f	NE_4	25	25	38	·02	·08
	Pembroke . . .	f	SSE_3	26	43	45	·05	·10
	Prawle Point . .	f	SSE_3	33	45	47	·17	·10
	Hurst Castle . .	f d	S_2	26	43	43	·21	·13
	Oxford . . .	o f	Z	18	36	41	·16	·04
28	Leith	f	Z	26	33	37	·03	...
	Shields . . .	f	SSW_1	30	35	38	...	...
	Spurn Head . .	f	Z	32	34	37	·04	·02
	York	f	Z	33	33	37	·05	·02
	Nottingham . .	o f	Z	32	34	41	·04	·05
	Ardrossan . . .	r f	NE_1	25	37	41	·08	·03
	Donaghadee . .	f	S_2	40	41	45	·12	·10
	Barrow . . .	f	NE_2	30	38	39	·09	·02
	Pembroke . . .	f	ESE_2	39	42	46	·10	·13
	Dover . . .	o f	NE_3	36	39	43	·08	·08
	London . . .	r f g	NW_1	36	37	44	·10	·08
	Oxford . . .	f	N_1	36	36	42	·04	·11
	Yarmouth . . .	f	ENE_1	33	36	39	·12	·07
29	Spurn Head . .	f	SSE_3	33	35	39	·02	·01
	York . . .	f	SSE_1	33	37	38	·02	·07
	Nottingham . .	o f	Z	34	40	43	·05	·08
	Liverpool . . .	f	ESE_2	33	39	42	·05	...
	Oxford . . .	o f	Z	33	41	47	·11	·23
30	Aberdeen . . .	f	Z	25	36	40	·19	·13
	Spurn Head . .	f d	SSW_2	34	36	41	·01	·01
	Nottingham . .	c f	SSW_1	37	39	46	·08	·03
	Barrow . . .	f	ESE_4	31	35	47	·12	·08
	Oxford . . .	o f	S_2	40	40	47	·23	·04
Feb.								
3	Roche's Point . .	f	S_4	46	47	50	·32	·56
	Pembroke . . .	f	S_4	46	47	47	·24	·29
	Prawle Point . .	f	S_4	46	48	50	·04	·18
	Yarmouth . . .	f	S_3	34	40	44	·23	·01
	York	f	SSE_1	30	42	49	·24	·15
4	Holyhead . . .	f	SSE_2	46	46	47	·37	·04
	Pembroke . . .	f	SSW_3	45	45	46	·29	·05

December, January, and February, of these there are 34, and their average temperature was 48°·6.

These figures show clearly that the anticyclonic fogs are cold fogs, while the strong wind fogs are essentially warm fogs.

As regards the relation of fogs to rain, it will be seen in the paper already quoted, and which was read in 1893, that out of 135 reports of fog accompanied by strong winds, 78, or more than half, "were either accompanied with, or followed immediately by rain, sometimes heavy rain, and in 18 cases the fall exceeded half an inch."

In the anticyclonic fogs under review in the present paper, the precipitation is scarcely ever measurable, *unless* the form of the isobars betrays some irregularity in the distribution of pressure, indicating a local tendency to assume cyclonic conditions. The precipitation, if measurable at all, amounts to only one or two hundredths of an inch, and would therefore usually be the result of dew.

The stations, moreover, are not by any means exclusively town stations, so that the dryness of the fog is not mainly due to impurity of the air due to smoke in large towns. It is, however, remarkable that in the fog of 1888, the warm anticyclone, the measurements of precipitation were much more frequent than in the other cases.

In the fog of 1881 there was an appreciable number of instances of fog reported when the distribution of pressure was cyclonic, and these have been examined on the same principles as have been applied to the anticyclonic fogs. The instances are given in Table III.

The average temperature at 8 a.m. given by the individual records was 34°·5, and was therefore 13°·7 higher than that of the purely anticyclonic fogs extracted from the same fog interval. The relation of the fog temperature to the minimum and maximum respectively, in the same sense as has been taken above, is as follows:—

TABLE IV.

Amount of Range.	Minimum.	Maximum.	Amount of Range.	Minimum.	Maximum.
0°	7	2	11°	1	...
1	7	5	12	4	1
2	7	5	13	...	2
3	5	6	14	1	...
4	2	11	15	1	...
5	2	2	16	...	2
6	4	3	17	2	...
7	1	6	18	2	3
8	2	...	19	...	...
9	1	...	20	...	...
10	...	...	21	...	1
				49	49

These figures do not show the contrasts between the two columns at all so clearly as the similar figures in the previous table.

It is, however, in regard of precipitation that these cyclonic fogs distinguish themselves from the others. Out of the 49 stations reporting

these fogs two only were rainless on both days, and in 37 cases rain fell on both days, in 20 of these cases exceeding 0·1 inch on one or other of the days. These cyclonic fogs were therefore essentially wet fogs.

We now come to the consideration of the anticyclonic fogs recorded at 6 p.m. For 1873 these reports were not available, for the *Daily Weather Reports* of that date gave no 6 p.m. observations.

TABLE V.—Anticyclones, 6 p.m.

December 1879.

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
Dec.				°	°	°	in.	
2	Holyhead	f s	ENE$_2$	32	33	37	·09	
6	Liverpool	f	ESE$_1$	23	27	32	...	
	Oxford	b f	Z	12	25	38	...	
	London	b f	N$_1$	13	28	34	...	
7	London	c f	Z	15	29	35	...	
8	Oxford	f	Z	20	30	39	...	
	Roche's Point	f	N$_2$	31	34	39	...	
9	Roche's Point	f	N$_2$	32	39	42	...	
11	Kingstown	f	Z	32	40	43	·01	
	London	b f	W$_2$	19	24	34	...	
12	Leith	f	Z	25	34	45	...	
	London	o f	Z	32	33	39	...	
	Yarmouth	f	NW$_2$	30	36	36	·03	
14	Yarmouth	o f	WSW$_2$	31	35	37	·02	
15	Spurn Head	f	W$_2$	36	40	41	...	
	London	f	Z	32	39	43	...	
	Oxford	o f	Z	35	38	46	·01	
	Yarmouth	f	Z	30	37	38	...	
16	Shields	f	SW$_2$	32	37	40	...	
	York	f	S$_2$	30	34	40	·01	
	London	f	Z	23	29	35	...	
17	York	f	ESE$_1$	29	35	37	...	
	Hurst Castle	f	NE$_2$	25	29	35	...	
	London	f	E$_1$	22	29	34	...	
	Cambridge	f	Z	23	28	32	...	
	Yarmouth	f	WNW$_1$	22	31	37	·02	
18	Holyhead	f	ENE$_2$	31	37	41	...	
	Liverpool	f	E$_1$	32	36	38	...	
21	London	o f	SSW$_1$	25	30	40	...	
22	London	f	Z	28	31	44	...	
23	Hurst Castle	f	E$_3$	27	36	42	...	
	Dover	o f	Z	29	33	38	...	
	London	o f	SW$_1$	23	31	37	...	
	Cambridge	f	S$_1$	23	32	35	...	
	Yarmouth	f	SW$_2$	27	30	33	...	
	January and February 1880.							
Jan.								
27	London	f	Z	16	21	34	...	
	Cambridge	f	WNW$_1$	16	23	40	...	
	Hurst Castle	f	Z	23	27	39	...	
28	Hurst Castle	f	E$_3$	26	30	33	...	
	London	f	Z	19	24	26	...	
	Yarmouth	b f	Z	17	27	28	...	

TABLE V.—ANTICYCLONES, 6 P.M.—*Continued.*

JANUARY AND FEBRUARY 1880.

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	At time of observation.	Maximum recorded next morning.	Rain. Recorded at time of observation.	Recorded next morning.
Jan.				°	°	°	in.	
29	Hurst Castle	f	ENE_1	29	35	40	·05	
	London	f	SSE_1	18	26	39	...	
	Yarmouth	f	SSW_1	22	30	34	·02	
30	Roche's Point	f	SSW_2	45	45	50	·18*	
31	London	f	Z	27	29	55	...	
Feb.								
1	London	f	SSE_1	27	34	48	...	
2	Scilly	f	WSW_4	45	50	53	·05	
3	Scilly	f	SSW_3	45	50	51	·06	
	Prawle Point	f	SSW_2	43	46	48	·11	
	Dover	o f	S_2	32	36	39	...	
	Oxford	o f	S_1	39	43	44	·08	
	Yarmouth	o f	Z	31	39	42	...	
4	Spurn Head	f	SW_4	34	39	44	...	
	Hurst Castle	f	ENE_1	33	37	39	·01	
5	Scilly	f	WNW_4	45	48	52	·08	
	Yarmouth	b c f	SW_1	31	39	44	·03	

* This was probably cyclonic.

JANUARY 1881.

Date.	Station.	Weather reported at time.	Wind.	Minimum recorded at time.	At time of observation.	Maximum recorded next morning.	Recorded at time of observation.	Recorded next morning.
Jan.								
4	Leith	f	NW_1	27	43	46	·01	
	Ardrossan	f	Z	29	37	50	...	
	Liverpool	f	NNE_1	37	41	45	...	
	Roche's Point	f	NNW_4	40	42	46	...	
5	Stornoway	f	Z	24	32	36	...	
	Leith	f	W_1	26	30	35	·01	
	Ardrossan	b f	NE_2	28	35	42	...	
8	Nairn	f	Z	20	20	25	...	
	Donaghadee	f	SE_1	29	38	41	...	
	Ardrossan	c f	ENE_3	25	26	29	...	
9	Mullaghmore	f	ESE_3	24	29	33	...	
	Donaghadee	f	W_2	30	32	36	...	
14	Nottingham	f	Z	2	18	22	...	
	Ardrossan	b f	E_1	18	25	31	...	
15	Mullaghmore	f	SW_1	23	26	37	·02	
	London	f	WNW_1	11	18	26	...	
17	Shields	f	Z	10	23	26	...	
	York	f	N_1	7	9	29	...	
18	Ardrossan	b f	NE_1	18	27	33	...	
20	London	b f	W_1	12	17	31	...	
23	Leith	f	W_1	12	25	34	...	
	Parsonstown	f	Z	21	33	34	·08	
24	Spurn Head	f	SSW_2	14	18	25	...	
	York	f	S_1	17	23	27	...	
	Hurst Castle	f	ENE_3	19	26	30	...	
	Oxford	f	Z	16	17	23	...	
	Yarmouth	o f	SW_2	18	28	32	...	
25	Spurn Head	f	S_1	13	23	34	...	
	York	f	SSW_1	13	14	18	...	

TABLE V.—ANTICYCLONES, 6 P.M.—*Continued.*

JANUARY 1888.

Date.	Station.	Weather reported at time.	Wind.	Temperatures.			Rain.	
				Minimum recorded at time.	At time of observation.	Maximum recorded next morning.	Recorded at time of observation.	Recorded next morning.
Jan.				°	°	°	in.	
9	Donaghadee	f	S_2	43	45	48	·01	
	Barrow	f	WSW_1	38	46	46	·03	
	Holyhead	f	SSW_3	43	47	48	·01	
	Pembroke	f	ESE_2	40	44	46	·02	
	Scilly	f	SE_3	45	46	50	·03	
	Prawle Point	f	Z	41	46	49	·01	
	Hurst Castle	f	Z	38	42	46	·02	
	Jersey	o d f g	NNE_2	43	48	49	·01	
	Dungeness	f	W_3	36	44	47	·02	
	London	o f	Z	34	45	47	...	
	Oxford	f	Z	32	39	46	...	
10	Shields	f	W_2	37	44	48	...	
	York	f	ESE_1	31	42	43	·01	
	Donaghadee	f	S_2	42	45	48	...	
	Barrow	f	SE_3	38	43	45	·03	
	Liverpool	f	WNW_1	38	42	47	·02	
	Prawle Point	f	ESE_3	40	44	46	...	
	Hurst Castle	f	E_1	34	40	45	·02	
	Dungeness	f	W_2	35	40	41	·02	
	London	f	Z	32	36	46	·01	
	Oxford	f	Z	30	34	41	...	
11	Spurn Head	f	NNE_1	35	40	41	·01	
	York	f	Z	32	35	39	·02	
	Loughborough	f	ENE_1	28	30	32	...	
	Barrow	f	NE_2	31	38	40	·02	
	Liverpool	f	ESE_1	30	32	39	...	
	Holyhead	f	Z	35	36	42	·01	
	Prawle Point	f	E_3	37	43	44	...	
	Jersey	f	E_2	36	39	41	·01	
	Hurst Castle	f	E_1	31	38	42	·02	
	Dungeness	f	Z	34	36	40	·02	
	London	f	Z	32	35	40	·01	
	Oxford	f	Z	30	32	34	...	
	Yarmouth	f	NNE_1	36	38	42	·02	
12	Aberdeen	f	S_1	28	34	37	...	
	Shields	f	SW_3	29	33	37	...	
	Spurn Head	f	SSE_2	32	34	37	·01	
	York	f	NNE_1	28	31	34	·01	
	Loughborough	f	SSW_1	28	31	32	·01	
	Donaghadee	f	SW_2	38	41	42	...	
	Barrow	f	NE_2	31	35	35	...	
	Liverpool	f	SE_1	30	36	38	·01	
	Prawle Point	f	ENE_3	38	42	44	...	
	Scilly	o f	E_1	43	45	45	...	
	Jersey	f	NE_3	34	42	43	...	
	Hurst Castle	f	E_1	33	35	38	·01	
	Oxford	f	Z	30	33	33	·02	
13	Wick	f	Z	40	44	46	·02	
	Aberdeen	f	Z	30	37	38	·03	
	Spurn Head	f	SW_1	31	32	40	...	
	Loughborough	f	WNW_1	28	30	35	·01	
	Ardrossan	o f w	Z	40	42	43	...	
	Malin Head	c f d	S_2	38	41	44	...	
	Pembroke	f	E_2	33	34	38	...	
	Oxford	f	SW_1	28	31	32	...	
14	Malin Head	o f	Z	38	41	41	...	

TABLE V.—FOGS WITH STRONG WINDS, 6 P.M.—*Continued.*

Date.	Station.	Weather reported at time.	Wind.	Temperatures. Minimum recorded at time.	Temperatures. At time of observation.	Temperatures. Maximum recorded next morning.	Rain. Recorded at time of observation.	Rain. Recorded next morning.
1876.				°	°	°	in.	
Feb. 28	Scilly . .	f	SW_6	50	52	55	·16	
April 7	Scilly . .	f	ESE_6	47	49	54	...	
1877.								
Feb. 8	Scilly . .	f	W_6	48	52	53	·09	
Aug. 27	Scilly . .	f	SW_7	58	62	64	·15	
1878.								
Feb. 15	Hurst Castle .	f d	SW_6	44	47	50	·07	
Nov. 24	Scilly . .	o f	SSW_6	46	47	54	·13	
1879.								
Jan. 7	Scilly . .	f	WNW_6	42	50	52	·50	
Mar. 5	Pembroke . .	f	WNW_6	42	45	48	.04	
June 19	Scilly . .	d f	SSW_8	54	57	59	.22	
1880.								
Jan. 5	Scilly . .	f d	SSW_6	47	51	52	·10	
Feb. 29	Scilly . .	f	SW_6	50	49	52	·04	
Mar. 4	Pembroke . .	f	WSW_6	45	48	48	·02	
1881.								
Feb. 13	Scilly . .	f d	S_7	48	50	52	·25	
Aug. 12	Scilly . .	r f	WSW_6	56	61	61	·25	
1882.								
June 5	Scilly . .	d f	SW_6	53	57	58	·58	
July 14	Scilly . .	r f	S_8	55	59	63	·35	
Aug. 20	Scilly . .	f d	SW_7	58	61	63	·02	
1883.								
Mar. 21	Hurst Castle .	f	ESE_6	34	39	45	·06	
June 26	Wick. . .	f	ESE_7	49	58	58	...	
Oct. 13	Scilly . .	f d	S_6	54	57	58	·22	
1884.								
May 15	Pembroke . .	f	SW_6	49	51	52	·01	
1885.								
Feb. 26	Pembroke . .	f	SSW_6	47	47	48	·37	
June 18	Pembroke . .	f	SSW_6	53	54	58	·04	
Sept. 15	Pembroke . .	r f	SSW_6	59	59	60	·11	
1886.								
Mar. 1	Hurst Castle .	d f s	SW_8	34	45	45	·50	
Mar. 22	Roche's Point .	f	SSE_6	45	47	50	·35	
Mar. 26	Scilly . .	f d	SSW_8	47	51	52	·08	
"	Pembroke . .	f	SSW_7	45	46	47	·60	
June 14	Hurst Castle .	f	SW_6	51	55	62	·01	
1887.								
Jan. 19	Pembroke . .	f	W_6	42	48	49	·27	
Jan. 26	Scilly . .	c f	SSE_6	47	50	54	·01	
Mar. 3	Scilly . .	o f	E_6	41	47	48	...	
1888.								
June 15	Hurst Castle .	f	WSW_7	50	55	56	·04	
Dec. 5	Scilly . .	f	S_6	52	55	55	·17	
1889.								
Jan. 31	Scilly . .	f	W_6	48	52	52	.04	
Feb. 1	Dungeness . .	f	WSW_6	39	48	48	...	
	Jersey . .	o p f	W_6	42	51	52	·05	
Dec. 21	Scilly . .	r f	SW_7	48	51	53	·45	
1890.								
Jan. 9	Scilly . .	f p	SW_6	48	53	53	·12	
	Prawle Point .	f	SW_7	45	52	52	·15	

As in the case of these records, the maximum and minimum temperatures extracted belong to the same interval of 24 hours, we can extract the figures for range of temperature, and these show conclusively that these fogs do not obliterate diurnal range. The figures in the table indicate number of instances of occurrence of each degree of range.

TABLE VI.—RANGE WITH ANTICYCLONIC FOGS AT 6 P.M.

Amount of Range.	1879.	1880.	1881.	1888.	Strong Winds.
0°	...	...	...	...	...
1	...	...	...	...	2
2	...	...	...	1	1
3	...	...	...	3	3
4	...	...	2	6	3
5	2	3	2	7	12
6	4	2	2	12	4
7	1	4	1	5	5
8	4	1	1	7	2
9	3	...	2	6	2
10	4	1	1	...	2
11	3	2	2	5	3
12	3	1	2	1	1
13	...	1	2	1	...
14	1	...	2	2	...
15	4	1	2	...	...
16	1	1	1	...	...
17	...	...	...	...	...
18	...	1	...	...	...
19	1	...	2	...	...
20	2	...	1	...	...
21	1	2	2	...	...
22	...	...	2	...	...
23	...	...	...	...	...
24	...	1	...	...	...
25	...	...	...	...	...
26	1	...	...	...	...
27	...	...	...	...	...
28	...	1	...	...	...

It will be seen from this table that the warm anticyclone of 1888 was the only one which was strikingly characterised by low figures for diurnal range. The other figures, especially those for 1881, show a much more uniform distribution of the ranges between 4° and say 20°. A few instances exceeded 20°, and one reached 28° in 1880.

In the case of the fogs with strong winds, it can only be said that the range was less in general than with the anticyclonic fogs.

As regards precipitation there is little calling for notice, for the rain entries are, with very few exceptions, the same as have been discussed before.

Before concluding this report, it may, perhaps, be allowable to make a short digression, and compare the actual temperatures recorded in

London at the time of fog with the deaths from diseases of the respiratory organs, as shown by the reports of the Registrar-General. It is very generally thought that the death-rate increases with the intensity and duration of the fog, but the figures we have been dealing with do not confirm this idea.

In the fog of 1873 (Dec. 3-15), the memorable Cattle-Show fog, there were 7 days of fog in London, the average temperature at 8 a.m. was 30°·4, and the climax of the mortality was for the week ending December 20th, with 1112 deaths from those diseases.

In the fog of 1879 (Dec. 3-27) there were 13 days of fog in London, the average temperature at 8 a.m. was 28°·9, and the climax of the mortality was for the week ending December 20th, with 799 deaths from those diseases.

In the fog of 1880 (Jan. 26—Feb. 6) there were 8 days of fog in London. The average temperature at 8 a.m. was 26°·0. The climax of the mortality was for the week ending February 7th, with a total death-rate of 48·1 per thousand—a rate unequalled since the last cholera epidemic. There were no less than 1557 deaths from those diseases.

In the fog of 1881 (Jan. 5—Feb. 4) there were 6 days of fog in London. The average temperature at 8 a.m. was 18°·8, and the climax of the mortality was for the week ending January 29th, with 702 deaths from those diseases.

Lastly, in the warm anticyclone of 1888 (Jan. 9-14) there were only 4 days reported with fog in London. The average temperature of these was 33°·8, and the climax of the mortality was for the week ending January 21st, with 591 deaths from those diseases.

If we summarise these figures we have for the London district for the periods under review—

Year.	Number of Days of Fog, 8 a.m.	Average Temperature at 8 a.m.	Deaths from Diseases of Respiratory Organs.	Excess above Average.
1873	7	30°·4	1112	561
1879	13	28°·9	799	288
1880	8	26°·0	1557	1118
1881	6	18°·8	702	249
1888	4	33°·8	591	29

The column for the death-rate is thus shown to be unconnected in any simple way with those for either the temperature or the duration of the fogs.

The general outcome of the enquiry has been to show that there are at least two distinct classes of phenomena described under the generic name of fog.

In one of them no rainfall takes place, the temperature is low in the mornings, and there is a considerable rise of temperature during the day.

In the others rainfall does take place, the temperature is high in the morning, frequently approaching, or even equalling, the maximum for the day. These wet fogs frequently set in when an anticyclone is breaking up, even temporarily.

There is also, from the experience of five well-marked fogs in London, no direct relation traceable between the actual temperature and the death-rate.

No strictly sea fogs have been investigated, as the number of stations available for the purpose would not suffice. They appear to be decidedly wet fogs, from all accounts we can gather, but more information respecting them is in every respect desirable.

I cannot conclude this report without stating that I have received very great assistance from Mr. F. Gaster in its compilation.

[The subjoined extract from the *American Meteorological Journal*, vol. xii. No. 9, January 1896, appears to be sufficiently interesting for insertion.—Ed.]

EXTRACT from a Paper on "Atmospheric Phenomena in the Arctic Regions in their relation to Dust." By Prof. WM. H. BREWER.

NONE of the fogs are so white and opaque as those seen south of lat. 50°. There is much exaggeration in the popular descriptions of fogs. We often hear of fogs at sea where nothing can be seen a hundred feet away. In fact such fogs are rare on either sea or land. Indeed, it is rare that fogs are so opaque that large dark objects cannot be seen two hundred feet.

I saw none in the Greenland seas in which we could not see several hundred feet, and usually very much farther. The fogs were all very much more transparent than those we met with south of New England and Nova Scotia on our voyage out and back.

The fogs were, however, as a rule, very much wetter and more misty. Often, when the fog was so transparent that we could see a half a mile or even a mile from the ship, the water would drip like rain from the rigging and every exposed surface, and our beards and clothes be rapidly covered with fine drops.

Even those surface fogs resting on the water under a clear sky, which shut out the horizon, but with the sun shining through from above, were very wet. The ship's rigging and even our beards would drip. On our return, and when in the dense, opaque fogs we met with south of New England, I noticed the marked contrast in their wetness, so to speak, where at times we could not see a ship's length, but the air did not appear as if entirely saturated. The decks of ship would dry after scrubbing, and other exposed objects would dry even in the fog. The dust particles in the air over these southern waters were ample to collect all the moisture, while in the Greenland fogs condensation went on as if there was not nearly dust enough in the air to supply the demand.

DISCUSSION.

Mr. F. GASTER said that it had been suggested by some of the Fellows that the prevalence of fog at 8 a.m. only had been considered in Mr. Scott's paper, and that it frequently happened that a fog in the morning cleared away during the day, so that in such instances the diurnal range of temperature was considerably greater than it would have been had the fog continued throughout the day. This circumstance, however, probably had less influence upon the results arrived at in the paper than might appear at first sight, as all the fog observations utilised were made in mid-winter, when the effect of the sun in causing diurnal range of temperature was very slight, and the occasions selected were

those when the fog was not intermittent but continuous. It would have been better, undoubtedly, to have taken only those fogs which prevailed during the whole day, but such information was not available. It was, however, perfectly clear to all who had had any experience of fogs, that they were of two classes—wet and dry—and the figures given in the paper showed that the temperature of the air at 8 a.m. was about 10° higher during the prevalence of wet fogs than it was during dry fogs. The dry (or anticyclonic) fogs were generally accompanied with intense cold and a calm air in the morning—the springing up of any breeze immediately causing the fog to dissipate. The air was dry, and there was little sensation of dampness, although grass, fences, etc., were often coated with hoar frost, due to frozen dew; but the pavements and roads were dry, and water was not deposited on clothing. These fogs were specially powerful in affecting weak chests, and causing great irritation of the mucous membranes. The wet (or cyclonic) fogs occurred with high temperature, often with strong winds, and while they did not irritate the throat or eyes, they felt wet, and usually produced severe colds, without, however, giving rise to bronchial attacks. He considered that incomplete as the information was upon which the results given in the paper were based, it had been used to the best advantage, and the conclusions arrived at formed an important addition to our knowledge of fogs. It was evident that hitherto very little had been known concerning fog, for in Mr. Abercromby's book *Weather*, fog or haze was never once mentioned in the index, nor referred to at any length in the body of the work.

The Hon. F. A. R. Russell said that living as he did at an elevation of 630 feet above sea-level, he had many opportunities of observing wet or cyclonic fogs, but that in that situation dense anticyclonic fogs were rare. He had no doubt that these two manifestations of fog were quite distinct, and appeared in different conditions. He had made no special observations on the fog of 1873, although he was in it at the Cattle-Show, but the fog of 1880 he observed very closely, and it was by far the most intense he had ever known in London. Objects became invisible at 4½ yards distance; a fog was usually considered dense when objects at 30 to 40 yards were obscured. The paper just read showed the desirability of regular observations on the density or intensity of London fogs; otherwise these are hardly comparable with one another. The fog of 1880 affected the mortality much more heavily than any of the others, more than doubly as much as the next in order, that of 1873. The fog of 1888 was the least fatal, the death-rate showing hardly any increase, and in 1881 the death-rate was but slightly affected. He thought there was evidence to prove that a dense fog was much more fatal if acting simultaneously with a very low temperature, and especially that mortality increased greatly beyond a certain degree of intensity of a dense fog. It is only in large smoky towns that any appreciable increase of illness and mortality has been noted. Country fogs are harmless. Dr. Russell, the medical officer for Glasgow, has stated in a recent work that during a fog in 1874-5 the death-rate rose to 67 per 1000, and that in this case the fog was more remarkable for density than the frost for intensity. The present paper indicated several points of interest in connection with the influence of London fogs on health, which deserved investigation.

Mr. R. H. Curtis said he gathered that the principal object of the paper was to show that fog did not annul the diurnal range of temperature, but in this he thought it failed. The method adopted for the investigation was not only unsafe, but it was really very misleading. If an observation of fog was reported at 8 a.m. the assumption was made that the fog had prevailed sufficiently long as to embrace the preceding minimum—which might have occurred at any time in the previous 24 hours, and that it continued long enough to cover the succeeding maximum, which similarly might not be reached till the close

of the following 24 hours. Such an assumption was evidently quite unwarranted. It was stated in the paper that the selected periods dealt with were all "well-marked instances of protracted and general fogs," and if this were really the case it might perhaps afford some degree of justification for the method adopted. But in order to test the statement he had examined for each of the periods the records kept at the Kew Observatory, in which the weather is recorded five or six times between 10 a.m. and 10 p.m. each day, and in which also is entered the weather between the times of observation, so that it forms a fairly continuous weather record. The result of the examination showed that with possibly one exception, that of 1888, none of the periods could justly be called "foggy" at Richmond. In one period to which special attention was called—that of 1873—there was but one foggy day, whilst such notes as "bright and clear overhead," and "fair above," are frequent. The fact probably was that in London there was a great deal of smoke fog, a phenomenon which frequently coexisted with fine bright weather just outside the town limits, and which is due to an entirely different cause to the white (water) fogs, which alone are experienced in rural and coast districts. It was unfortunate that the paper did not deal with selected stations, for which continuous weather records could be obtained, and with the temperature records for the periods during which it was certain that the fog continued.

Mr. W. H. Dines said that he thought the plan adopted of finding the range of temperature was the best of which the information obtainable admitted. Of course there were exceptions, but the minimum temperature mostly occurred at night, a few hours before the 9 a.m. fog observation, and the maximum for the succeeding 24 hours about midday, a few hours after 9 a.m. He could not agree with Mr. Gaster as to there being two distinct kinds of fogs; the irritating effect of some fogs being, in his opinion, simply due to the smoke of a large city. Where he lived in the country, 17 miles from London, a fog irritating to the throat or eyes was an absolutely unknown phenomenon. Also he thought that wetness, apart from actual rain, was only a question of degree, and not a fundamental difference. He believed that if a fog lasted for more than two or three hours it invariably wetted the trees to some extent, if the temperature were above 32°, or deposited some hoar frost on them if the temperature were below 32°.

Dr. R. Barnes said it was impossible to estimate the effect of fogs upon mortality until a month or more had elapsed. Disease might be started or aggravated during the fogs, but the fatal issue might not come for several weeks. It was usual to dwell upon the smoke caught in the London fog as the active noxious element. But this is not the only agent. The fog and the attendant atmospheric conditions entailed other ills. The diffusion of gases, a great factor in aërial purification, was greatly impeded or arrested. When a Medical Officer of Health he had made many observations upon this subject. For example, inspecting gas factories he found that in foggy weather the gases escaping from the works were held in a concentrated form in and near the works. And in London there were many other sources of contamination in foul emanations from the ground, sewers, manufactories of various kinds. These were held in suspension near the surface of the earth in a concentrated form, and thus contributed greatly to the injurious action of the air we breathed. In clear bright air, even apart from wind, the law of diffusion of gases acted freely in dispersing noxious emanations.

Mr. H. Southall said that the position of his house on the side of a hill frequently enabled him to observe the height to which the fog extended, and he recollected that the fog of 1873 attained a higher altitude than that of 1881, when a great deal of bright weather prevailed, and the fog did not extend higher than 400 feet above mean sea-level. As regarded temperature, in 1873 the

maxima were low, and the range of temperature certainly much less than in 1881. Possibly the effect upon mortality was greater in 1873, because the fog occurred earlier in the season than in 1881.

Mr. R. C. Mossman said that from his own experience on Ben Nevis he was sure that both wet and dry fogs were observed there, and it was no uncommon thing to have a difference of a few tenths of a degree between the dry- and wet-bulb thermometers during fog. The number of dust particles, too, differed greatly in a dry and in a wet fog. Regarding the relation between temperature and mortality, he had found in working up the temperature of Edinburgh in relation to diseases of the respiratory system, that the greatest death-rate occurred not at the period of lowest temperature, but when the variations of temperature were greatest and the alternations between warm and cold weather were sudden.

Mr. G. J. Symons said that if hourly observations of weather, as well as instrumental records, had been available, they would have been of great service for the purpose of Mr. Scott's inquiry into the conditions of weather accompanying fog. Regarding the composition of fogs he was certainly of opinion that dry fogs occurred in other places besides London and similar large towns. It would be a simple matter to ascertain to what extent fogs differed in their degree of saturation if the records from the Society's stations were examined, and the differences between the dry- and wet-bulb thermometers were extracted for all those occasions on which fog was reported at the time of observation. Recognising the difficulty of the subject he would rather give no definition, but if pressed he should consider "dry" fog and "haze" as one and the same thing, both being the result of anticyclonic conditions, the former occurring in the winter season and the latter in the summer. The term "mist," he thought, well expressed what a "wet" fog was. The damp and unpleasant condition of London pavements, to which reference had been made, was often due to the paving-stones being colder than the superincumbent air and the consequent condensation of moisture upon them. The measurement of the density of fog was not an easy matter, as the visibility of objects depended so much on the amount of illumination they received, and not upon the intensity of the fog itself. Concerning London fogs he was inclined to think that they were rather more dirty in modern times than they were years ago, but possibly this opinion was largely due to the fact that the progress of years made him more sensitive of the discomforts occasioned by London fog.

Mr. H. S. Wallis inquired what caused the obscuration in a dry fog when it was not the result of the smoke of large towns.

Mr. R. H. Scott, in reply, said that at Kew Observatory attempts had been made to measure the intensity of fog by means of a frame with four panels tinted in regular gradations, but it was found that the whole frame was either visible or invisible. The fact that the observer knew that there were four panels to be looked for biased his judgment as to actually seeing them. It was now the practice to enter the visibility of a series of objects at known distances from the observatory, extending from a few feet to three or four miles, but here the illumination was much affected by the sun's azimuth. Thus Mortlake church was in shadow in the morning, but the sun shone on it in the afternoon, so that under the same conditions of fog it would be more visible in the afternoon. Mr. Scott was disposed to think that several of the fogs Mr. Russell reported at Hind Head were cloud caps, or driving clouds. The fog of 1888 was very general, and the Malvern photograph which had been mentioned, showed that the top of the Worcestershire Beacon was not much above the surface of the fog, the latter was therefore extended to a great height. As to the irritation of the respiratory organs caused by London fog, that was of course due to the fact that these fogs usually occurred when there was no wind to remove smoke. Mr. Russell's

remark as to the enormous mortality at Glasgow during fog was probably due to the number of chemical factories there. In answer to Dr. Barnes, Mr. Scott said that the figures he had quoted represented the highest mortality in any individual week during the fog period, usually at the close of that period. Regarding Mr. Symons's suggestion that hygrometrical observations should be taken during fog, Mr. Scott considered that it would be very interesting, but difficult, as the wet-bulb would be often close to the freezing-point. It had been occasionally noticed on balloon ascents that on passing through a cloud the air was not saturated. The cause of obscuration in fogs was, of course, the presence of water globules, and in the case of town fogs, according to Dr. Frankland, these globules were coated with some matter of an oily nature, resulting from fires, which prevented any evaporation taking place, and so, perhaps, prevented any sensation of dampness. It was a known principle in chemical manufactories that a liquid could be kept from rapid evaporation by a film of oil on its surface.

Analysis of Greenwich Barometrical Observations from 1879 to 1890, with special reference to the Declination of the Sun and Moon.

By Major H. E. RAWSON, R.E., F.R.Met.Soc.

[Read December 18, 1895.]

In the course of some investigations into the movements of the centres of anticyclones in the Northern Hemisphere, I was led to examine the *Greenwich Meteorological Observations* for the last twelve years then available to the public, 1879 to 1890. The object in view was to obtain the relative mean barometrical pressure for each period of the year when the Sun and Moon, separately and combined, conjointly and opposed, are north and south of our equator, that is, have north or south declination. The results are interesting, and as the matter does not appear to have engaged the attention of the Society in this form before, I venture to bring my conclusions to the notice of the Fellows.

Mean Height of Barometer, Greenwich, 1879.

Moon North Declination.			Moon South Declination.		
Period ending	No. of Days.	Mean for Period. in.	Period ending	No. of Days.	Mean for Period. in.
Jan. 12	12	29·701	Jan. 25	12	29·869
Feb. 8	13	29·778	Feb. 21	12	29·121
Mar. 7	13	29·831	Mar. 20	12	29·890
April 4	14	29·542	Apr. 17	12	29·395
May 1	13	29·652	May 14	12	29·954
May 28	13	29·753	June 10	12	29·577
June 25	14	29·644	July 8	12	29·583
July 22	13	29·577	Aug. 4	12	29·841
Aug. 18	13	29·682	Aug. 31	12	29·614
Sept. 15	14	29·726	Sept. 28	12	29·832
Oct. 12	13	30·116	Oct. 25	12	29·732
Nov. 8	13	30·156	Nov. 21	12	30·008
Dec. 6	14	29·766	Dec. 18	11	30·392
Dec. 31	12	30·133			
Total .	184	Mean 29·7898	Total .	155	Mean 29·7545

In the *Greenwich Observations* the height of the barometer for each day is obtained by taking the mean of 24 hourly values, all readings being corrected and reduced to 32°. From the *Nautical Almanac* are ascertained the dates when the Sun and Moon cross the equator. One example (p. 65) will show the steps by which the final summary given below is arrived at.

Thus in 1879 the mean height of the barometer for all the periods when the declination of the Moon was north was 29·7898 in., and when south 29·7545 in. The height of the barometer on the days when the Moon was on the equator is not included.

Similarly, the mean height of the barometer for the period when the declination of the Sun was north was 29·667 in., and when south 29·875 in.

The year 1879 is only given because of its being the first of the series, and we shall see later on that it was an exceptional year as regards the relative mean heights of the barometer during the lunar periods.

Proceeding in the same way for the rest of the series, we get the results shown in the summary. The years are arranged not in ordinary sequence, but in such order as will bring out most clearly the relative mean height of the barometer when the declination of the Moon is north and when it is south, for this is one of the special points I wish to bring out. Thus in 1890 the mean barometrical pressure, when the declination of the Moon was north, exceeded that when its declination was south by 0·151 in. daily: in 1879 it exceeded it by 0·0353 in. But these were the only two years out of the twelve when the mean height of the barometer was greater with the Moon north of the equator than with the Moon south. In 1882, the last year in the table, the mean height with the Moon south exceeded by $\frac{1}{10}$th in. daily the mean height with the Moon north of the equator.

Summary of Greenwich Barometrical Observations, 1879 to 1890, with Special Reference to Declination of the Sun and Moon.

Year	1890	1879	1884	1881	1889	1883
Moon North Declination. Days.	185	184	160	178	179	157
,, South ,, ,,	154	155	179	160	159	182
,, in Equator ,,	26	26	27	27	27	26
Mean Height of Barometer:						
(1) Moon North Declination. Inches.	29·8587	29·7898	29·8136	29·7874	29·7942	29·7682
(2) ,, South ,, ,,	29·7077	29·7545	29·8171	29·7992	29·8094	29·8113
Excess of Pressure:						
(1) Moon North Declination. ,,	0·1510	0·0353	...	...	...	...
(2) ,, South ,, ,,	...	...	0·0035	0·0118	0·0152	0·0431
Annual Mean Barometer . .	29·790	29·771	29·813	29·778	29·791	29·783
Mean Height of Barometer:						
(1) Sun North Declination. Inches.	29·745	29·667	29·797	29·773	29·773	29·799
(2) ,, South ,, ,,	29·835	29·875	29·829	29·783	29·809	29·767
(3) Sun S. Dec., Moon N. Dec. ,,	29·890	29·926	29·823	29·780	29·878	29·725
(4) ,, N. ,, ,, N. ,, ,,	29·826	29·652	29·803	29·794	29·710	29·811
(5) ,, S. ,, ,, S. ,, ,,	29·772	29·835	29·846	29·796	29·844	29·885
(6) ,, N. ,, ,, S. ,, ,,	29·642	29·673	29·791	29·802	29·774	29·737

Year	1885	1886	1880	1888	1887	1882
Moon North Declination Days.	158	158	178	177	173	174
,, South ,, ,,	180	181	161	162	166	164
,, in Equator ,,	27	26	27	27	27	27
Mean Height of Barometer :						
(1) Moon North Declination. Inches.	29·7362	29·6998	29·7951	29·7370	29·7956	29·7123
(2) ,, South ,, ,,	29·7794	29·7521	29·8533	29·8090	29·8802	29·8126
Excess of Pressure :						
(1) Moon North Declination ,,	...	...	...	...	...	...
(2) ,, South ,, ,,	0·0432	0·0523	0·0582	0·0720	0·0846	0·1003
Annual Mean Barometer. . .	29·753	29·734	29·809	29·777	29·840	29·757
Mean Height of Barometer :						
(1) Sun North Declination. Inches.	29·762	29·766	29·755	29·755	29·844	29·743
(2) ,, South ,, ,,	29·744	29·702	29·863	29·799	29·836	29·771
(3) Sun S. Dec., Moon N. Dec. ,,	29·719	29·607	29·814	29·725	29·778	29·709
(4) ,, N. ,, ,, N. ,, ,,	29·753	29·791	29·660	29·749	29·812	29·715
(5) ,, S. ,, ,, S. ,, ,,	29·767	29·753	29·938	29·833	29·862	29·841
(6) ,, N. ,, ,, S. ,, ,,	29·791	29·751	29·768	29·785	29·898	29·783

Besides showing the mean height of the barometer when Sun and Moon are separately north or south of the equator, the table also gives the mean height for periods when Sun and Moon are both north or both south, and when one is north and the other south. The following are the principal results obtained from examining these twelve years:—

1. When the Moon is south of the equator, the mean height of the barometer is higher than when it is north, in 10 years out of the 12.

2. When the Sun is south of the equator, the mean height of the barometer is higher than when it is north, in 8 years out of the 12.

3. Taking the declination of both Sun and Moon conjointly into consideration:

(*a*) Moon North—the mean height of the barometer is higher when Sun is north than when it is south, in 7 years out of the 12.

(*b*) Moon South—the mean height of the barometer is higher when Sun is south than when it is north, in 9 years out of the 12.

(*c*) Sun North—the mean height of the barometer is higher when Moon is south than when it is north, in 8 years out of the 12.

(*d*) Sun South—the mean height of the barometer is higher when Moon is south than when it is north, in 9 years out of the 12.

(*e*) Moon South and Sun South—the mean height of the barometer is higher when Moon and Sun are both south than when they are both north, in 10 years out of the 12.

The two years referred to in (1) are 1890 and 1879 (eleven years' interval), and are remarkable as the only two years in the series in which the orbital movements of the Moon closely resemble one another. If the curves representing the Moon's motion relative to the equator are plotted they will be found very much alike, the Moon crossing the equator on the same day, almost universally, during each year. That is, the relative movements of the earth round the Sun, and of the Moon round the earth, are the same for these two years, the interval between which, as will be noticed, is eleven years. The years 1884 and 1881 somewhat resemble one another in the same respect, and they stand next to one another in the series. The year 1887 differs the most widely of all the

series from 1890 and 1879, and stands at the opposite end of the series from them. The two years referred to in 3 (*e*) are 1890 and 1886.

Buchan, by his isobarometric charts of the mean pressure of the globe for January and July, has made us familiar with the great alterations in the distribution of the two belts of high pressure encircling the globe north and south of the equator, which the Sun causes by the barometric and thermometric changes it sets in motion. We would naturally turn to this explanation for the results in the Table, but it will not suffice. The number of days in each year when the declination of the Sun and Moon is south simultaneously differs too slightly from the number of days when the declination of each is north simultaneously to account for such consistent results as those which appear in the Table.

It would seem that we have something still to learn from a more careful analysis of barometrical observations specially referred to the declination of the Moon, such as are recorded in the Meteorological Observations made at Batavia. If the results obtained in this paper are carried into investigations of rainfall and movements of anticyclones, they are found to have an interest which warrant their being brought to the notice of the Society.

DISCUSSION.

The President (Mr. R. Inwards) said that in perusing this paper the question naturally arose as to whether Greenwich was a suitable place for such an inquiry, and also whether twelve years was a sufficiently long period. The late Sir E. Sabine, in some remarks printed in *Observations made at the Magnetical and Meteorological Observatory at St. Helena*, vol. i. 1840-3, had stated concerning the question of the barometrical measurement of the lunar atmospheric tide: "We may conclude that, on the general average, the barometer at St. Helena stands four thousandths of an inch higher at the two periods in each day when the moon is distant six hours from the meridian." This of course was a very small amount. Sir E. Sabine further mentioned that the observations at St. Helena were subsequently made according to the lunar hours eight times in each lunar day. It did not appear, however, that the observations referred to had ever been published, so that it was impossible to ascertain whether they proved confirmatory or otherwise of the published figures for previous years. St. Helena was certainly a favourable place for such an investigation. Luke Howard believed in an eighteen years' cycle, and also imagined it possible that the moon would be found to radiate heat to the earth. The investigations of Lord Rosse had proved that some heat was reflected from the moon's surface, but the amount of it was extremely small.

Mr. G. J. Symons said that Major Rawson deserved every credit for the hard work he had devoted to the preparation of this paper, the result of which was embodied in the summary given. He (Mr. Symons) thought that the figures put forward merited careful consideration, for the evidence they afforded of a regular movement in one direction could not be lightly set aside. Luke Howard had worked up three years' observations, and had found the difference between the barometric pressure with the moon in south declination, and that with the moon in north declination, amounted to ·090 inch, being even more than Major Rawson had found. Mr. Symons had taken out the departure from the general mean of the various values given by Major Rawson and made them as under:—

	in.		in.
Moon N . . .	– ·009	Moon S . . .	+ ·016
Sun N . . .	– ·018	Sun S . . .	+ ·018
Sun and moon N .	– ·027	Sun and moon S .	+ ·048
Sun N, Moon S . .	– ·017	Sun S, Moon N . .	– ·002

Mr. C. HARDING said that, while fully appreciating the labour involved in this investigation, Greenwich could not, he thought, be considered a suitable place for the purpose, as non-periodic changes, such as the passage of cyclones, exercised so large an influence upon the observations. Thinking that the values for 1879 might in some way be erroneous, he had referred to the Greenwich volume, and had carefully gone through the figures, and was pleased to testify, as evidence of the accuracy of Major Rawson's work, that he found them perfectly correct. He, however, pointed out that if the readings for February were excluded from the discussion, the mean barometer for 1879, when the declination of the Moon was south, would be in excess of that when the declination was north, and this would leave the year 1890 as the only exception in this respect.

Mr. R. H. SCOTT remarked that Sir E. Sabine always said that it was of little use working at an investigation of lunar tides unless the observations were made within the Tropics, where the periodic changes were well marked. M. Garrigou-Lagrange had published several papers on the same subjects as Major Rawson in the *Annuaire de la Société Météorologique de France.*

Major H. E. RAWSON, in reply, said that he had used his best endeavours to secure accuracy in his calculations, and felt assured of their accuracy, as he had checked the observations with curves he had plotted in order to verify the results. He had specially checked 1879 and 1890, as he did not want to have any exceptions among the twelve years. It was in the process of checking that he was struck with the similarity between the curves of the Moon's motion for the two years, and was interested to find evidence of an eleven years' cycle just now for all the curves, 1880 resembling 1891, 1881 resembling 1892, and so on. [Perhaps a warning is necessary here that the eleven years' interval cannot be pushed back to 1868, 1857, etc.]

METEOROLOGICAL OBSERVATIONS TAKEN AT MOJANGA, MADAGASCAR.

BY STRATTON C. KNOTT, F.R.MET.SOC., H.M. VICE-CONSUL.

(Communicated by R. H. Scott, F.R.S.)

[Read December 18, 1895.]

OWING to the operations of the French in Madagascar the observations at Mojanga were temporarily discontinued from the end of 1894, and it has been thought to be of interest to print the results, as far as they go, in continuation of the paper previously laid before the Society. In the previous communication (*Quarterly Journal*, vol. xxi. p. 21) the values were given for the two years, April 1892—March 1894. The present paper carries the figures on for the succeeding nine months. The yearly values for 1892-3, 1893-4 are reprinted for the purposes of comparison.

Pressure.—The highest pressure previously reported was not exceeded in the period now under review, but the barometer fell to 29·616 in. at 5 p.m. on April 29, 1894 (with heavy rain, strong wind-force 7, and lightning), the lowest reading previously recorded being 29·689 in. on January 23, 1893, at 5 p.m.

Temperature.—The mean temperature values did not greatly vary from those previously given. The mean maxima, however, fell as low as 83°·6 in June 1894, the previous lowest being 84°·5 in July 1893. In three of the months the extreme maximum fell below 90°, which happened only twice in the preceding two years, while in two months out of the nine the minimum exceeded 70°.

The coldest month was June, with a mean temperature of 74°·8, and the warmest November, with a mean of 82°·2, the previous extreme means being 74°·7 in July 1893 and 82°·9 in April 1892.

Radiation.—The grass minimum thermometer was broken on September 17th. The lowest temperature observed with it, April to September, was 53°·4 on June 29th. The highest observed maximum in sun (black bulb in vacuo) was 166°·8 on November 11th.

Rainfall.—The only points to notice are that the rainfall in September 1894 was higher than in either of the preceding Septembers, namely 0·59 in. on four days, as against 0·07 in. in 1892 and 0·32 in. in 1893; and that April also had a heavier fall than usual, 8·45 in. as against 2·43 in. in 1892 and 4·11 in. in 1893. Of the amount in 1894 4·69 in. fell in one day during a gale.

Hygrometry.—The hygrometric values agreed closely with those of the preceding periods, but the greatest individual difference between the dry bulb and wet bulb was larger than had before been observed, reaching 25°·9 at 11 a.m. on November 8th.

This paper has been drawn up by Mr. J. A. Curtis.

RESULTS OF OBSERVATIONS MADE AT MOJANGA, MADAGASCAR.

Long. 46° 19′ 15″ E. Lat. 15° 43′ 0″S. Height above Mean Sea Level 134 feet.

1894.	Mean Pressure at Sea Level.		Air Temperature.						Humidity.					
					Means.		Extremes.		Depression of Wet Bulb.		Tension of Vapour.		Relative Humidity.	
	11 a.m.	5 p.m.	11 a.m.	5 p.m.	Min.	Max.	Min.	Max.	11 a.m.	5 p.m.	11 a.m.	5 p.m.	11 a.m.	5 p.m.
	in.	in.	°	°	°	°	°	°	°	°	in.	in.	%	%
April .	29·982	29·905	85·1	85·1	73·2	88·8	68·3	92·8	10·7	8·9	·679	·749	56	62
May .	30·060	29·994	82·4	81·6	70·3	85·2	66·1	88·0	10·7	8·8	·615	·663	56	61
June .	·157	30·081	79·6	79·8	65·9	83·6	62·8	86·2	13·7	12·1	·461	·513	46	50
July .	·145	·071	80·3	79·2	66·5	84·9	62·0	88·8	13·4	9·9	·482	·577	46	59
Aug. .	·138	·053	81·7	80·9	67·1	86·8	64·2	90·4	15·1	11·5	·460	·559	43	54
Sept. .	·103	30·021	84·4	79·8	69·5	87·1	66·8	92·1	15·4	8·4	·505	·635	43	62
Oct. .	·032	29·955	87·5	82·5	73·2	90·6	69·1	96·5	15·7	8·5	·558	·697	43	63
Nov. .	30·022	·939	87·3	82·7	74·0	90·4	70·8	96·5	14·0	8·2	·621	·714	50	64
Dec. .	29·948	29·872	83·2	82·5	74·2	86·2	71·0	93·3	7·0	6·3	·779	·786	70	71
April to Dec. 1894	30·065	29·988	83·5	81·6	70·4	87·1	62·0	96·5	12·9	9·2	·573	·655	50	60
April 1892 to March 1893	30·028	29·958	84·5	82·2	71·6	88·7	60·0	98·8	12·3	8·9	·610	·675	51	61
April 1893 to March 1894	30·049	29·972	83·9	82·0	71·0	87·2	61·1	95·5	12·3	9·0	·600	·668	51	60

1894.	Amount of Cloud.		Rainfall.		Weather, No. of Days of					Wind, No. of Observations of								
	11 a.m.	5 p.m.	Total.	Greatest Fall.	Rain.	Thunder Storm.	Clear Sky.	Over-cast.	Gale.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
			in.	in.														
April	5·0	4·5	8·45	4·69	8	10	9	9	2	5	2	5	20	3	2	3	16	4
May	3·5	2·6	·58	·43	2	2	15	4	0	4	3	4	18	4	9	2	17	0
June	1·2	3·6	...	...	0	0	14	0	0	0	1	3	31	12	5	2	5	1
July	2·4	3·9	...	...	0	0	16	4	0	0	2	1	25	6	12	5	11	0
Aug.	2·5	4·8	·59	·34	4	1	14	6	0	1	4	2	30	1	6	6	12	0
Sept.	1·7	2·7	·05	·05	1	1	19	2	0	0	1	2	11	2	6	1	37	0
Oct.	1·8	1·6	·70	·45	5	8	22	0	0	1	0	3	11	2	3	7	35	0
Nov.	4·7	5·6	7·38	2·37	8	10	8	7	0	2	4	2	8	1	3	1	38	1
Dec.	7·8	8·0	8·30	1·61	17	13	2	22	0	7	6	1	4	2	5	1	30	6
April to Dec. 1894	3·4	4·1	26·05	4·69	45	45	119	54	2	20	23	23	158	34	51	28	201	12
April 1892 to March 1893	3·1	3·6	57·26	4·13	71	94	171	45	2	136	59	69	78	54	80	62	171	21
April 1893 to March 1894	4·0	4·3	51·91	5·43	75	88	127	78	0	59	42	66	149	46	49	37	262	20

EXPERIMENT ILLUSTRATING THE FORMATION OF THE TORNADO CLOUD.

By W. H. DINES, B.A., F.R.Met.Soc.

[Shown at the Meeting on November 20, 1895.]

PLATE 1.

I HAVE never seen either a tornado or a waterspout, hence I cannot say that the cloud which I hope to show you is like the real phenomenon; but I think you will agree with me in believing that it bears a striking resemblance to the photographs and illustrations which most of us have seen.

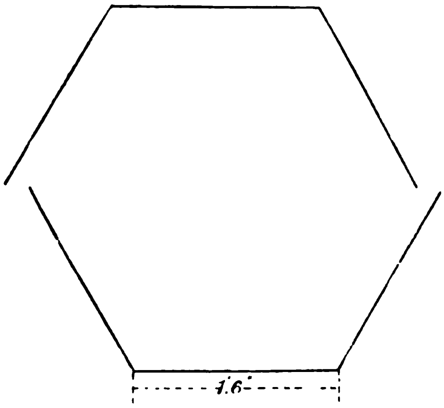


FIG. 1.

The apparatus required is very simple; I describe it in the hope that some of the Fellows may be able to experiment further upon the subject. Probably the sizes are immaterial, but here I have six pieces of common window glass, 2 feet by 1 foot 6 in., arranged in two sets of three each. The edges are smoothed, and the three sheets are fastened together by twine, so as to form a kind of folding screen. They are placed on a table in the position shown in Fig. 1. On the top a wooden panel of the requisite size is placed, with a round hole 7 in. in diameter, in the

centre. In the hole there is a ventilating fan, driven by hand, by a band and pulley wheel. A few feet of stove-pipe with a gas jet burning in it, will do as well as the fan. In the centre at the bottom there is a shallow vessel containing water, heated by a spirit-lamp underneath, for the purpose of obtaining sufficient vapour to form the funnel cloud. On turning the fan an upward current of air is produced in the centre, and the cloud is formed.

In the following four particulars it is very similar to the actual phenomenon :—

1. There is a distinct rotary motion round the centre, increasing in violence as the centre is approached. This can be seen by suspending a piece of cotton-wool by a thread, and gradually bringing it near the cloud.

2. There is a strong up-draft. This also may be proved by the cotton-wool, but it is difficult to get the wool into the actual cloud on account of the centrifugal force; if however, it can be got in, it will probably be carried up and lodged in the fan.

3. There is a great decrease of pressure in the centre. In the natural phenomena this is not apparent to the eye, but is proved to exist by the way in which the walls of a house are forced outwards in all directions, and most notably perhaps by the fact that bottles are often uncorked by the passage of a tornado. It is shown here by the hump raised on the water at the foot of the cloud.

All three of the above particulars are well shown by dissolving some soap in the water, and stirring it up so as to obtain a good supply of soap-suds on the surface. It is very apparent how the soap-bubbles are drawn in towards the cloud along a spiral path, there raised up in a kind of heap, carried up the cloud, and then thrown violently out by the centrifugal tendency of the whirl.

4. The cloud column is distinctly hollow. In the West Indian hurricanes, which we may look upon as tornados on a large scale, there is a clear space in the centre in which the clouds break away and blue sky is seen above. The explanation given by Ferrel does not seem to me altogether satisfactory, but I cannot suggest any better, neither can I explain why the experimental cloud should be hollow.

I also wish to show a very suggestive result. On turning the fan slowly, and producing thus a trifling up-draft, the cloud is formed. Now increase the pace of the fan, causing a stronger up-draft, and the first effect is that the cloud disappears,[1] soon, however, to be formed again with greater intensity. Now decrease the pace of the fan to its first rate and maintain it at that; again the cloud disappears for a time, again to be reproduced, but after a longer interval than in the first instance. May not this suggest a reason for the manner in which tornados, hurricanes, and also the cyclones of these latitudes, vary in strength as they pass from place to place.

The mechanical principle on which both the real and artificial phenomena depend is a simple one, and I do not propose to refer to it, since it is fully explained in books on Meteorology, notably in Ferrel's works, and in Davis's *Elementary Meteorology*. But I must point out how, from

[1] I am indebted to Mr. R. H. Curtis for the observation of this fact.

ADO CLOUD.

FIG. 3.—Showing the rotary motion of the steam round the cloud column.

the experimental point of view, the one fundamental requirement for the success of this experiment is a good up-draft in the centre. No arrangement of parallel but opposed currents side by side that I have been able to devise, will form the cloud, but given a sufficient up-draft, it is very difficult to arrange the glass screens so that it shall not be formed. Another thing is noteworthy. The fan used is hardly capable of producing by itself a decrease of pressure equal to $\frac{1}{8}$ in. of water, at least not with the means here used of turning it, but the decrease of pressure in the cloud amounts, I think, to 1 or 2 ins. of water; certainly, since the water at the foot of the cloud is $\frac{1}{2}$ to $\frac{3}{4}$ in. above its proper level, the decrease of pressure must greatly exceed $\frac{1}{8}$ in. Of course the decrease is due to the centrifugal action of the whirl, and we have an experimental illustration of the way in which areas of low barometric pressure are formed.

In the natural phenomena the twist is provided for by the rotation of the earth, but here it is obtained by the arrangement of the screens. The direction of rotation may be varied at pleasure by altering the direction of the air as it enters; but, as stated above, it is not easy to arrange the glass screens so that the formation of a cloud in some part of the enclosed space may not occur.

The experiment is on too small a scale compared with the cyclones of a thousand miles or so in diameter, which often pass over the British Isles in the winter, to throw much light on the cause of their formation; but the evidence, as far as it goes, is distinctly in favour of Ferrel's as opposed to Hann's theory, and strengthens the opinion I have always held as to the former being the correct one.

Since the above was in type my attention has been called to Weyher's experiments as described by Prof. E. Mascart (*Journal de Physique*, December 1889).

I can only state that at the time, I was in total ignorance of any similar experiments having been previously described, and although the details of his arrangement and mine are essentially different in the manner of obtaining the angular momentum of the whirl, the principle, in so far as it relates to the central up-draft, is doubtless the same.

The Figs. in Plate 1 have been reproduced from photographs taken by Mr. R. H. Curtis.

DISCUSSION.

Captain D. Wilson-Barker remarked that he had witnessed numerous waterspouts in the course of his experience at sea, and he had never seen any other artificial representation which so truly resembled the actual phenomenon as the whirling column of steam produced in Mr. Dines's experiment.

Mr. F. C. Bayard pointed out that in some illustrations of waterspouts which appeared in the *Quarterly Journal* (vol. ix. p. 159), a sack-like cloud, with a pointed end, was shown to be hanging over the whirl in the water where the spout was forming. He noticed that there was no descending cloud in Mr. Dines's experiment, but the motion was all upwards.

Mr. W. B. Tripp enquired whether a better effect would be produced if the glass surrounding the tray of water were raised a little to permit the entrance of air underneath.

The President (Mr. R. Inwards) said that the shape of the column of

steam was exactly like that of the sand-whirls which he had frequently seen in Mexico and Peru.

Mr. W. MARRIOTT said that the experiment clearly demonstrated the uplifting effect produced in tornados or whirlwinds ; and it was easy to understand how it was possible for showers of fish, shells, etc., which were occasionally heard of, to be experienced. Houses and other objects had been known to be lifted a considerable distance in American tornados. He hoped that it would be possible to obtain a photograph of the column of steam produced by Mr. Dines's apparatus, so that it might be reproduced for publication in the *Quarterly Journal.*

Mr. H. N. DICKSON asked if Mr. Dines had made any experiments in which the vertical height of the column of vapour was small in proportion to its diameter. The apparatus exhibited represented the conditions under which a tornado was formed, but in a cyclone the part played by the rotational component was more important, relatively to the others.

Admiral J. P. MACLEAR remarked that the experiment was the most perfect illustration of the lower part of a waterspout that he had ever seen. In natural waterspouts dense clouds were always present, from which a funnel-shaped mass, having the apex downwards, depended, and met the rising water. He supposed it would not be possible to produce this upper part by means of any experimental apparatus, as the fan would have to be between the cloud and the water.

Mr. W. H. DINES, in reply, said that in the natural phenomena the column was hundreds of feet high, and the upper part reached the level of the cloud formation. Under these circumstances the relative humidity of the air in the upper was much greater than in the lower part ; and as the pressure decreased steadily as the centre was approached, and less dynamic cooling was required to condense vapour from the damper air above, the bag or funnel-shaped cloud, that had been alluded to, was formed at the top. The means by which the draft was produced were immaterial, but the stronger the up-draft the stronger the tornado, and by connecting the opening at the top with an ordinary dwelling-house chimney, he had been able to empty the tray of water in a minute or two, the water being splashed out, and some of it even carried up and deposited on the wood at the top, nearly two feet above the tray, thus illustrating the lifting power mentioned by Mr. Marriott. The height of the fan above the water did not seem to matter, but he had not experimented with any great variation of size.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 20, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

ALFRED HENRY FRANCK CLARKE, Rednal, Barnt Green, Birmingham ;
GOLDING BIRD COLLET, L.R.C.P., Shelley House, Worthing ;
Capt. WILLIAM ELLIOTT, Filbert Cottage, Toddington, Beds ;
Capt. THOMAS FREE, 2 Billiter Avenue, E.C. ;
Major JOHN MACPHERSON GRANT, 32 Hans Place, S.W. ;

HERBERT HENRY LAW, Assoc.M.Inst.C.E., 17 Victoria St., S.W.;
Rev. CLAUDE ROBERT LONGFIELD, B.A., Brandrum House, Monaghan;
GEORGE RUDD THOMPSON, F.C.S., 57 Dock Street, Newport, Mon.; and
ROBERT DE COURCY WARD, M.A., Harvard University, Cambridge, Mass.,
were ballotted for and duly elected Fellows of the Society.

The following communications were read:—

"ON THE ORIGIN OF THE COLD WEATHER STORMS OF THE YEAR 1893 IN INDIA, AND THE CHARACTER OF THE AIR MOVEMENT ON THE INDIAN SEAS AND THE EQUATORIAL BELT, MORE ESPECIALLY DURING THE SOUTH-WEST MONSOON PERIOD." By JOHN ELIOT, M.A., F.R.S. (p. 1).

"THE DIURNAL VARIATION OF WIND VELOCITY AT TOKIO, JAPAN." By CHARLES DAVISON, M.A., F.G.S. (p. 38).

Mr. W. H. DINES also showed his Experiment illustrating the formation of the Tornado Cloud (p. 71).

December 18, 1895.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., President, in the Chair.

ROBERT JOHNSTONE, Kingston, Jamaica;
ARCHIBALD LAWSON, Baker Street, Weybridge;
WILLIAM PAGE MAY, M.D., B.Sc., 49 Welbeck Street, W.; and
JOHN WOOD PAULIN, Opoho, Dunedin, New Zealand,
were ballotted for and duly elected Fellows of the Society.

Mr. F. GASTER and Mr. M. JACKSON were appointed Auditors of the Society's Accounts.

The following communications were read:—

"NOTES ON SOME OF THE DIFFERENCES BETWEEN FOGS, AS RELATED TO THE WEATHER SYSTEMS WHICH ACCOMPANY THEM." By ROBERT H. SCOTT, M.A., F.R.S. (p. 40).

"ANALYSIS OF GREENWICH BAROMETRICAL OBSERVATIONS FROM 1879 TO 1890, WITH SPECIAL REFERENCE TO THE DECLINATION OF THE SUN AND MOON." By Major H. E. RAWSON, R.E., F.R.Met.Soc. (p. 65).

"METEOROLOGICAL OBSERVATIONS TAKEN AT MOJANGA, MADAGASCAR." By STRATTON C. KNOTT, F.R.Met.Soc. (p. 69).

Mr. SCOTT exhibited some specimens of the illustrations in the *International Cloud Atlas*, now being prepared for publication.

CORRESPONDENCE AND NOTES.

Globular Lightning.—Mr. C. A. Nankivell, of Torquay, has forwarded the following account from the *Western Morning News* of what appears to have been an instance of globular lightning:—

"A thunderstorm broke over Brixham, Devon, on December 18, 1895, shortly before 10 a.m. Heavy showers of rain had fallen at intervals from an early hour up to the time of the storm, when a bright blue sky with heavy white clouds and sunshine existed. The wind, which was blowing very moderately from the South-east, still continued without any variation. Two heavy flashes of lightning and two terrific peals of thunder were all that was seen and heard in the town generally, but in a field at Furzeham, part of which is occupied as a twine-walk, and where two men and a boy were at work, an electric ball or thunderbolt was observed by them in the west, and to travel in an easterly direction, tearing up the ground in its course until it reached the small wheel-house, where the boy sits to turn a small wheel for the spinners. The door of this small house was closed and the fluid striking it shattered its lower part, and passing on knocked a hole right through the wall, and, making its exit through, flew upward, striking the gable end of the roof of Mr. J. Varwell's ropery, knocking down the masonry and partially unroofing the establishment. It then entered the rope-walk and travelled 20 yards, damaging the side wall in its course, until it reached four men who were at work close together in making yarn. The names of the men are William Morey, James Lowe, Edward Mitchell, and Samuel Webber. Morey, who happened to be stooping at the time, was struck on the top of the head and killed instantly; Lowe, who was close to him, was struck across the abdomen and laid helpless, though he never lost consciousness; Mitchell received a severe shock in both legs and was knocked down, but was not injured. Webber escaped free. As soon as possible medical aid was sent for, and in a short time Drs. Elliott and Hayward were on the spot, and every effort was made by them to restore animation in Morey, but without avail, and his body was conveyed to his home. The injuries to Lowe were of such a nature as to necessitate his being kept at the residence of the foreman of the works until one o'clock, when he was taken home. His condition is critical. A railway porter and another man in the employ of Derry and Co., carriers, both of whom were in the goods shed, received severe shocks. One said he felt dazed and had pains about his body. Fishermen at the moorings in the outer harbour report that the electric fluid ran along the chains on the decks of their vessels, and that on Monday night at sea the crew of one fishing vessel saw three electric or phosphorescent balls on their mast and rigging. Such are often seen, but seldom more than one at a time. William Morey was single, and thirty-eight years of age. Hundreds of persons visited the ground in the neighbourhood of Mr. Varwell's Ropery, where the ground is torn up for upwards of a hundred yards. Such a thing has never been known in the district before."

In reply to an inquiry Mr. Nankivell wrote:—"I may say that before I sent you the newspaper cutting I had seen the foreman of the ropeworks, in the hope of supplementing or correcting the details, and I had also questioned the reporter of the *Western Morning News*. The former confirmed the general accuracy of the account, but I am sorry to say that I did not succeed in obtaining any trustworthy information as to the size, colour, or rate of travel of the globe, except that the latter was described as slow. The ball was first noticed in a field to the west of the ropery, and travelled in an easterly direction (that is to say, against the wind), taking its course parallel and close to the wall of the field, which abuts on and terminates in the wall of the rope-walk, a long low building several hundred feet in length. The line of travel was therefore fairly straight, whether it was determined by the inherent motion of the globe itself or the direction of the walls, the wall of the field and that of the rope-walk, forming practically a straight line. The unfortunate man who was killed was stooping to detach a hank of yarn from the metal hook at the end of a length of rope lying on the floor, when he was struck, and apparently killed immediately.

I am unable to say whether the lightning expended itself within the building, or passed outside ; if the latter, it did so without disruptive effects, as I was shown only some slight grazes on the wall, made in its passage after having struck the man. No more lightning was seen that morning, but the storm was renewed between ten and twelve at night, and the house of the foreman adjoining the ropeworks was struck. I regret my inability to add anything more in the way of description of this occurrence."

Tree struck by Lightning.—It is so seldom that any person actually sees a tree struck by lightning that the following account by an eye-witness of one, an oak, struck at Ewhurst at 8 a.m. on August 22, 1895, will be interesting.

F. Williams, a plumber, was passing along the road about 100 yards from the tree, when there was a sharp discharge of lightning simultaneously with a crack of thunder ; the tree, in the direction of which he was looking, was completely shivered and the entire bark of the lower part thrown off, some of it falling into the road. He describes the explosion as like a shell bursting, there was a great flare of light, and a cloud of smoke (? steam) above the tree.

Apparently the explosion occurred at the junction of the large branches with the trunk. No stripping or effects of lightning were visible on the upper branches.

J. P. MACLEAR.

Results of German Balloon Observations.—As is well known the German Balloon Association has carried out many ascents, and Dr. Assmann, in a paper in the *Meteorologische Zeitschrift*, has given a short account of the principal results obtained, which may be summarised as follows :—

1. The temperature is found above the level of 12,000 feet to be decidedly lower than had been concluded from previous ascents ; this is due to improvements in the instrumental outfit.

2. The rate of decrease of temperature is found to be uniform throughout the ascents, but possibly increasing with altitude.

3. The last-named result is probably due to a relatively increased temperature between the levels of 6000 and 12,000 feet, the strata in which cloud formation is most active.

4. The seasonal change of temperature in connection with changes of weather extends to a considerable altitude, but at about the level of 15,000 feet a nearly constant temperature prevails.

5. The inversion of temperature in winter and at night is apparently a regular phenomenon up to the level of 3000 feet. This phenomenon has been noticed without the appearance of any cloud between the different strata. It was usually connected with differences in the direction of drift of the different strata.

6. The formation of cumulus in the neighbourhood of a depression extends to an unexpected altitude, and under favourable conditions the tops of the cumuli were inclined towards the depression.

7 The upper surface of a cloud area showed the same thermal and electrical relation to the conditions of the air stratum above as is noticed at the earth's surface. This confirms a prediction of Prof. von Bezold.

8. The conditions of exchange of air between anticyclones and cyclones have been thoroughly explained, and obey a simple law.

9. It is nearly certain that the electrical potential does not increase with height, and at considerable altitudes this potential appears to approach a constant value. This tends to show that all atmospheric electricity comes from the earth, and no independent electricity occurs in the air, but clouds may act as a fresh "earth."

10. The humidity was frequently found extremely low at moderate heights,

even as low as 1 per cent relative humidity, but great variations were found to exist between different cloud strata.

Various other results have come out, and it will be very interesting to see what light these will throw on the work already done.

Lakes and Climate.—Dr. Willi Ule, whose work on the lakes of Northern Germany is well known, published recently in the *Naturwissenschaftliche Wochenschrift*, a short paper on the influence of lakes on climate. He states the effects produced by lakes on the climate of the neighbouring districts as follows: The average annual temperature of lake-water being higher than that of the air, lakes exert on the whole a warming effect on the atmosphere. This is usually increased on account of the vertical distribution of water-temperature, but on the other hand diminished by the cooling effect of evaporation on the surface. Quite independent of the thermal reactions between water and air is the mirror-like action of the surface in reflecting the direct solar radiation into the surrounding air. The latter influence cannot be expressed statistically, and is probably only small. The supply of water-vapour yielded to the atmosphere is of value in moistening the neighbouring land, while the thermal changes over the water surface give rise to currents of air which would not otherwise exist. There seems, however, to be a marked absence of proof as to the extent to which the various influences really work.

Climate and Health.—The U.S. Weather Bureau, Washington, has commenced a new publication entitled *Climate and Health*, which is edited by Dr. W. F. R. Phillips. In the preface it is stated that it is presented to the professions to which it especially appeals as being almost wholly experimental in the sort of information it contains, and in the manner and plan in which the different statistics are published. It is offered not so much for its present value, as it is as an earnest of future endeavour, should the work it represents meet with the approval of the classes for which it has been particularly undertaken.

The data used in the climatic charts and tables are taken from the records of the meteorological stations of the Weather Bureau. The statistics of mortality and morbidity are furnished by special reports of public health officers and of physicians made directly to the Weather Bureau. An effort will be made to secure, as nearly as practicable, accurate and trustworthy statistics concerning the sanitary conditions prevailing from week to week.

RECENT PUBLICATIONS.

American Meteorological Journal, Vol. XII. Nos. 5-8. September—December 1895. 8vo.

The principal articles are:—Synchronous or simultaneous geographical distribution of hourly wind velocities in the United States: by Dr. F. Waldo (11 pp.).—Fog Signals and Meteorology: by Prof. H. A. Hazen (17 pp.).—Relations of the Weather Bureau to the science and industry of the country: by Prof. W. L. Moore (10 pp.).—The meteorological observatory on Monte Cimone, Italy: by A. L. Rotch (3 pp.). This is the only summit station in Italy, the observatories on Vesuvius and Etna being both situated on the flanks of these volcanoes. Monte Cimone is the culminating point of the Northern Apennines, attaining a height above the sea of 7100 feet, and rising from the Pass of Abetone, above the Baths of Lucca, into two peaks, on the northern and higher of which is the observatory.—Physiological effects of high altitudes:

by A. L. Rotch (2 pp.).—Psychrometer studies: by Dr. Nils Ekholm (6 pp.).—Meteorology as a University course: by R. de C. Ward (8 pp.).

Annuaire de la Société Météorologique de France. Tome XLIII. 1895. Fevrier—Mars. 4to.

The principal papers are:—Le clino-anémomètre: par le P. M. Dechevrens (5 pp.).—Relations nouvelles entre les mouvements barométriques sur l'hémisphère Nord et les mouvements en déclinaison du soleil et de la lune: par P. Garrigou-Lagrange (7 pp.).—Sur l'état physique de l'eau dans les nuages: par L. Besson (4 pp.).

Clouds and Weather: A Study for Navigators. By Capt. D. WILSON-BARKER, F.R.S.E., F.R.Met.Soc. 1895. 8vo. 22 pp.

This pamphlet, which is No. XI. of the *Shipping World Series*, is illustrated by twenty-two photographs of clouds taken by the author. Capt. Wilson-Barker divides clouds into two well-defined groups or types, viz. the *Cumulus* and the *Stratus*, and he gives five varieties of each of these types.

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. July—November 1895. 4to.

The principal articles are:—Ueber Kugelblitze: von Prof. F. Sauter (20 pp.). The author has already written several papers on globular lightning, and in the present one he recapitulates several of the best known accounts of the phenomena, so as to place its actual existence beyond a doubt. He then discusses the experiments and reasonings of Gaston Planté and von Leppel, and winds up with an appeal to the public to make careful observations of the phenomena, if they get a chance, inasmuch as none of the attempted explanations can be received as absolutely convincing.—Amsler's Theorie des Alpenglühens und ihre Widerlegung: von Dr. J. Maurer (15 pp.). At the meeting of the Swiss Naturforschende Gesellschaft in 1894 Prof. Amsler-Laffon brought forward a new theory of the after-glow so frequently observed in the Alps, and stated that he himself from the Rigi Scheidegg had seen the sun reappear after its setting; and that the whole explanation of the evening glow is to be explained on this principle. He also denies the existence of morning glow. Dr. Maurer's paper is intended to controvert this explanation on the authority and experience of Prof. von Bezold and Dr. Riggenbach; and he cites evidence to show that morning glow is just as pronounced a phenomenon as evening glow, and is exactly similar to it.—Zur täglichen Periode der Windstärke: von Prof. W. Köppen (5 pp.). This is divided into two parts. The first gives the epoch of maximum velocity at 67 stations in the United States. This part had been set up when Dr. Waldo's paper on the same subject came out, and Dr. Köppen proposes to discuss the results at which Waldo has arrived in a later paper. The second part deals with the geographical distribution of the afternoon maximum of velocity. This starts from the discovery that in North Italy the maximum falls decidedly later than in the rest of Europe in general, a result confirmed by the recent paper of da Schio on the wind at Vicenza. The paper concludes with a quotation of the epochs of maximum at mountain stations from Dr. Hann's recent paper on the Sonnblick.—Ueber den Temperatur unterschied zwischen Feld und Wald, und den Einfluss der Thermometeraufstellung auf die Ermittelung desselben: von Dr. J Schubert (8 pp.). This paper is an answer to that by Dr. Ebeymayer in the May No. of the *Zeitschrift*, in which doubt was thrown on Dr. Schubert's conclusions from his experiments with aspiration thermometers in comparing temperatures in the forest and in the open. Dr. Schubert first discusses the exposure, and points out that the

larger size of a screen does not insure accuracy in the indications of the enclosed thermometers. He also points out that screens with open bottoms do not afford any protection against radiation, so that a bottom of laths is always to be recommended. Dr. Schubert has found, as regards thermometers laid on the surface of the ground, that the difference between the indications in the wood and in the open is slight in the mornings, but at noon it rises to 10° C., and even to 20° C.; so that, according to him, screen observations taken in the shade are not comparable with those taken in sunshine. He concludes by maintaining that the results obtained from the Bavarian system of double stations, in the forest and outside, give a greater difference in temperatures, etc., than comes out from observations taken with aspiration instruments.—Die Reibung atmosphärischer Luft und die Druckvertheilung: von M. Möller (4 pp.). This paper is intended to show that the friction of the wind on the surface of the earth has been estimated at a far lower value than it really possesses.—Sollen die Beobachtungen der Luftfeuchtigkeit auf's Meeresniveau reducirt werden?: von A. Woeikof (3 pp.). This is one of the author's *Zeit- und Streitfragen*, and it is prompted by the recent paper of Kaminskij's "Der jährliche Gang der Feuchtigkeit in Russland," in which the vapour tension is reduced, but not so the relative humidity. Dr. Woeikof shows that the formula of reduction is that given by Hann in 1874, which applies to the free atmosphere and not to mountain stations. This mistake leads to very strange conclusions. The non-reduction of the relative humidity also brings out some extraordinary results. Dr. Woeikof concludes by saying that pressure is the only element of which the reduction to sea-level makes a pretence to accuracy.—Die Witterungsverhältnisse im bayerischen Alpengebiete und dessen Vorlande am 9. bis 12. Januar, 1894: von F. Erk (14 pp.). This is a very interesting account of the results of certain balloon ascents carried on at Munich during an interval of very severe frost, giving evidence of very remarkable changes of temperature with level, and of up-and-down movements in the atmosphere.

Symons's Monthly Meteorological Magazine. October—December 1895. 8vo.

The principal articles are:—The British Association at Ipswich (12 pp.). This contains an abstract of the papers bearing on Meteorology, which were read at the Meeting of the Association.—Rainfall in Palestine in the second century (1 p.).—Belgian Rainfall: by A. Lancaster (2 pp.).—September 1895 (7 pp.). This gives some particulars of the exceptionally hot weather which prevailed during the latter part of September. It appears that over one-third of the kingdom the rainfall of the month was less than one-quarter of the average, and over three-quarters of the kingdom was less than half. Temperatures over 80° were recorded at many places from the 23rd to 29th.—Climate and Health (2 pp.).—The Climate of the British Empire in 1894 (3 pp.).

Weather and Disease: A Curve History of their Variations in recent years. By ALEX. B. MACDOWALL, M.A., F.R.Met.Soc. 1895. 8vo. 83 pp.

The author in the preface says that the primary object of this book is to give an idea of the way in which certain elements of our weather, and the mortality from some well-known diseases, have varied in recent years. While no direct attempt is made to trace the relations between weather and disease, the work done is, generally, rather in the way of furnishing data for comparison and study. The mode of exposition adopted is largely that of graphic curves; these, indeed, are the essence of the book. Most of the curves are "smoothed."

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY

VOL. XXII.] APRIL 1896 [NO. 98.

METEOROLOGICAL OBSERVATORIES.

BY RICHARD INWARDS, F.R.A.S., PRESIDENT.

An Address delivered to the Royal Meteorological Society, January 15, 1896.

As Meteorology is essentially a science of observation, the present discourse will be devoted to giving some scant and scattered details of a few of the different organised arrangements in various parts of the world, for carrying on researches into the constitution of the atmosphere, and the effects of changes in its condition from day to day. The subject of observatories is a wide one, and I shall not attempt to condense the account of the whole world's work in this direction into the talk of one short hour. There is a map which has been printed by Mr. Scott to illustrate his address[1] from this chair in 1885 on the condition of climatological observations over the globe, which is instructive as showing at one glance the points on the world's surface from which the weather was systematically observed ten years ago. The map is shown to be dotted over in nearly every quarter, but, as might be expected, the dots are closer together near the great centres of civilisation, while vast portions of the earth's surface, in desert plains and among mountains, on the oceans and in the polar regions, are practically barren in this respect, and the movements of the atmosphere there remain almost unstudied and unrecorded.

Ancient Observatories.

In early savage times there is no doubt that keen eye observations, and a system of weather-guessing, represented the whole science of meteorology, and any prominent rock or tree served the purposes of an observatory from whence the early hunters, fishers, or sailors anxiously scanned the horizon for signs of the weather to come. Such a primitive arrangement in New Guinea I now show you photographed, and you will

[1] *Quarterly Journal* vol. xi. plate 4.

see that it is merely a dwelling in a tree, on the top of which may be seen the anxious inhabitants peering into space—their sight, no doubt, sharpened by the consideration of the chances which determine the date of their next meal of fish or game.

Nilometer.

It is a long step from the look-out tree of the savage to the more scientific efforts of the Egyptians and Greeks, who certainly had systematic observations made in special buildings, and which structures might with truth be called observatories, though not supplied like ours with means and methods of a high and complicated order. The great pyramid has been claimed for such an observatory, and some writers suppose that, from an opening in its side, the learned priests watched the transits of the stars and the rising of the constellations, to determine the march of the various seasons suitable for agriculture, or for the irrigation of their people's lands. Then they had Nilometers at various points in the course of their river, by which they took accurate nöte of its height at any season. There were many of these structures, perhaps the oldest being that at Memphis. There is one on the island of Rhoda, near Cairo, which remains in full operation to this day, having been more than eleven centuries in existence, and it may be claimed as the oldest flood gauge, and therefore rain gauge, in the world. The older Nilometers are mentioned by Herodotus, Strabo, and others, while our own Shakespeare thus speaks of this matter in the play of Anthony and Cleopatra:

> They take the flow o' the Nile
> By certain scales i' the pyramid; they know,
> By the height, the lowness, or the mean, if dearth
> Or foison follow: the higher Nilus swells,
> The more it promises.[1]

Although Shakespeare was probably mistaken in placing a Nilometer in a pyramid, it is very wonderful that he should have known of it at all.

Messrs. Symons and Chatterton, in their paper[2] on floods last year, deplored the absence of systematic flood-marks on the Thames and Severn, and I commend the authorities to the ancient Egyptians for an example.

Temple of the Winds, Athens.

The Greeks inherited and sifted out all the wisdom of Egypt, and it, therefore does not surprise us to find in the very heart of ancient Athens, and almost under the shadow of the Acropolis, a building which may be claimed as an archetype of observatories, and which yet remains standing in the modern city.

I mean the little marble octagon tower called the Temple of the Winds. The eight sides of this temple are built to face the eight principal winds, and on each side is sculptured a human figure in high relief, and which represents, as far as a figure can, the character and qualities of the particular wind which it faces.

For instance, the North wind, which is cold, fierce, and stormy, is re-

[1] *Anthony and Cleopatra*, Act 2, scene 7.
[2] *Quarterly Journal*, vol. xxi. p. 189.

presented by the sculptured figure of a man warmly clad and blowing fiercely on a trumpet made out of a sea-shell.

The North-east wind, which brought, and still brings, to the Athenians, cold, snow, and hail, was figured by an old man with a severe countenance,

FIG. 1.—Temple of the Winds, Athens.

and who is rattling sling-stones in a shield, a good way of expressing emblematically the noise and power of a hailstorm.

The East wind, which brought, and still brings, to the Greeks, a gentle rain, favourable to vegetation, is expressed by the image of a young man

with flowing hair and open countenance, having his looped-up mantle filled with fruit, honeycomb, and corn.

Zephyros, the West wind, was indicated by the figure of a slightly clad and beautiful youth with his lap full of flowers. And so with the other winds all round the compass, each has its qualities fixed in stone by its appropriate sculptured figure, and we have here a most interesting evidence that the climate of Greece has not materially changed, at any rate in respect of winds, after the lapse of about twenty centuries.

The tower had a vane on the top made to represent a Triton, who turned with the wind, and waved a brazen rod over the figure which portrayed it. This tower, of which I show you a photograph (by the kindness of Mr. J. G. Wood, the translator of *Theophrastus*), is described by Vitruvius and other ancient authors, some of whom call it a horologium, and they suppose it contained a water-clock, or Clepsydra, to mark the hours during the night and in cloudy weather, when the fine sundials with which the building is decorated would not be in operation. This seems at first confirmed by certain pools and gutters which have been found in the floor, and which it would have pleased me very much to claim for some rainfall or evaporation-recording purposes.

The names of the various winds are written up on the faces of the buildings in good Greek letters, so that all might read whether Boreas or Notus, Apeliotes or Sciron—there is a sound and fury in the very names—were bringing to them comfort or disaster, as the case might be.[1] For those who could not read, there remained the emblematic signs which told them the story in stone, and which served like fossils in a rock, to carry down the tale even to our own days.

The principal use of the temple was probably in order that the devout might offer prayers and gifts in view of obtaining the wind and weather they most required for nautical and agricultural reasons. It must be confessed that the building was rather badly situated for a mere observatory.

Observatories.

About modern observatories, it is my intention to give a few descriptive particulars on—1st, National Observatories, of which our own at Greenwich is taken as a type; 2nd, Observatories in high places; and 3rd, a few notes on private observing stations, with perhaps some suggestions as to what may still remain to be done.

Royal Observatory, Greenwich.

A first order station is one at which continuous observations are taken with self-recording instruments; and I will take you, for an example, to the Royal Observatory at Greenwich, where, by the courtesy of the Astronomer-Royal, and with the kind help of our past President, Mr. W. Ellis, F.R.S., and of Mr. Nash, the present Superintendent of the Magnetical and Meteorological Department, I have been able to collect a little information. This, although it is not by any means new to many of our Fellows, may interest others who may not have had the opportunity of visiting the Observatory.

[1] Stuart and Revett, *Antiquities of Athens*, vol. i., where will be found numerous illustrations of the tower and its ornamentation.

On entering the building, after passing the various establishments devoted to astronomy and horology, we find the meteorological observatory snugly placed among the other edifices, and one's first notion is that the situation is much too confined. But it is to be remembered that most of the surrounding buildings have been erected since the establishment of the meteorological department, and that owing to the formation of the hill and the small space at disposal, some crowding became inevitable. There is room to hope that this will be remedied some day by removing the magnetical and meteorological part to some more commanding site.

The building containing the principal meteorological instruments is of

FIG. 2.—Royal Observatory, Greenwich.

wood, and of only one story in height. On account of the delicate magnets below in an underground apartment, there is no iron used in the structure, the place of nails being supplied by pegs of bamboo, while the stoves, pipes, and locks are all of copper or brass.

The building is in the form of a cross, and contains several rooms: one is used as a computing room, and in another, larger, is placed the standard barometer and the electrometer. Of the magnets underneath we will speak more anon. We shall first consider the out-door instruments, and imagine ourselves personally conducted to take a rapid view of what is going on in the observatory.

We note first the four thermometers which are sunk in the earth in order to take the temperature at different depths. No. 1 is at a depth of

24 French feet below the surface of the soil. The long and fragile stem of this thermometer was successfully placed in a deep hole in the gravel soil and packed up with sand, adding successively the 12 feet, 6 feet, and 3 feet thermometers. French feet were used in order that the results might compare with continental observations. During the first two years, 1847 and 1848, the thermometers were read every two hours; but the diurnal variations were found to be very small, and the readings have since been taken only once daily—at noon. The observations have been discussed by Prof. Everett and others. As might be expected variations of the deepest thermometer are much less than those of the thermometer nearest the surface, and also follow the surface variations by a much longer interval. The depth of the longest thermometer is not sufficient to give any valuable results as to the increase of the temperature of the earth with depth; it is the comparison of the changes of the three thermometers with those of the air thermometer that is the valuable point.

We then approach the two stands, or screens, carrying thermometers employed for taking the temperature of the air, and we look with some respect on the central dry bulb thermometer—which is the standard thermometer for Greenwich temperature. It is placed with the standard wet bulb on the older form of open stand set up in the time of Sir George Airy and Mr. James Glaisher, and used in its present form, with some slight modifications, ever since the commencement of observations in the year 1841. It is commonly known as the "Glaisher Stand," and it is so contrived that it can be turned round on its vertical axis, and so always be kept with its back to the sun, to secure a proper shade for the instruments. The other screen set up in the year 1887, and which is of the form familiar to most of you, is known as the "Stevenson Screen," and is of the pattern now used by the observers of our Society. Both screens carry, in addition to the dry and wet bulb thermometers, ordinary self-registering maximum and minimum thermometers for eye observation.

We now come to the shed under which is placed the apparatus for photographic registration of the dry and wet bulb thermometers first set up in the year 1848. Here in a light-tight box are the two thermometers so ingeniously arranged, that their indications are continuously photographed on a sheet of sensitive paper, fixed to an upright drum, which is slowly carried round by clockwork, so as to bring successively fresh surfaces under the beam of light, which passes through the clear glass of each thermometer tube, while it is of course impeded by the opaque columns of mercury, so that when the images are duly brought out there appear on the sensitive paper two broad traces, each bounded below by a horizontal wavy line, corresponding to the height of the mercury in the two tubes.

The register of the wet bulb stands immediately below that of the dry bulb. The light is automatically interrupted for a short time at every hour, producing on the developed sheet thin white columns, each for some definite hour, so that any change of temperature may be known as well as the exact time at which it occurs. The readings of these thermometers are reduced by comparison with those of the standard dry and wet bulb on the Glaisher or revolving stand.

If there were time, many interesting points could be mentioned, such as the extremely rapid fall of temperature that will, at times, take place on

the occasion of sudden changes of wind, notably in squalls. Again in frost, it is interesting to remark how, as the temperature passes below the freezing-point, the wet bulb record will show a fall of a degree or two below the freezing-point, and come back to it with a sudden leap when the wetted bulb has acquired a coating of ice, after which the record again begins to show the true variations due to evaporation from the frozen surface.

Here there are the solar and grass radiation thermometers for measuring the solar and the night radiation to the sky, and an ozone box for registering the amount of that form of oxygen in the air, notably very little in amount in the neighbourhood of a great city. Observations of the water of the river Thames were made for a great many years, the results being included in the Greenwich annual volumes. In late years these were made at Deptford, but the series came to an end in the year 1891. It seems a pity that some other points in the neighbourhood cannot be found for continuing such observations.

There are various rain gauges placed on the ground, near the thermometer screens, one on the top of the photographic thermometer shed, one on the top of the magnetic house, one on the roof of the old building fronting the park, and two at the Osler anemometer, one of these being self-recording. These two latter are 50 feet above the ground, and record only about three-fifths of the amount registered on the surface of the ground below. The self-recording rain gauge acts as follows. The rain is received in a vessel suspended by spiral springs. As the vessel becomes heavier it sinks with greater or less rapidity, according to the rate of the fall of rain. By means of a cord passing therefrom, over a pulley to a pencil, this rate of fall is recorded on a sheet of paper driven by clockwork. When 0·25 inch has been collected, the vessel automatically empties itself, the pencil returns to zero and begins again to record. The amount of rain falling during any given interval of time is readily ascertained.

With regard to the barometer, eye readings of the standard barometer are taken, and the variations of pressure are registered by photography.

The standard barometer is a plain looking instrument of Fortin pattern, made by Newman, and the tube has a bore of 0·565 inch. It is fitted with lamps and ground glass screens to assist the readings. In the year 1877 a very elaborate comparison was made by the late Mr. Whipple between this barometer and the Kew standard barometer, with the result that the difference between the two was found not to exceed ·001 inch, corresponding to a difference of only about one foot of level, or to that caused by a few grains of impurity in the mercury—one much less than the usual difference of reading as made by any two observers. For photographic registration a siphon barometer by a simple and effective plan, acting from a float in the shorter leg, is made to raise and depress a slotted screen, so that by a clockwork and photographic arrangement, similar in principle to that already described for the thermometers, a permanent pressure curve is continuously recorded. The slotted screen is carried by a lever of such length that the scale on the paper becomes magnified to rather more than four times the natural scale. This enables the finer oscillations, as in thunderstorms, to be better studied, and I may mention that this barometer, in common with all other self-recording

barometers throughout the world, distinctly recorded in 1883 the passage of the air wave caused when Krakatoa, an island on the other side of the globe, was rent in two by a volcanic eruption.

On the top of the magnetic building we find the sunshine recorder of the Campbell-Stokes pattern burning, by means of a lens, a trace on a card in the usual way. Daily records of sunshine have been maintained at Greenwich since the year 1876. Near the sunshine instrument is a small, open, but well protected, thermometer screen carrying a dry bulb and maximum and minimum thermometers, for the purpose of comparing the results at this altitude, 20 feet from the ground, with the results of the standard thermometer at 4 feet above the soil.

On the top of the Observatory tower, which has formed a landmark since the time of Charles II., is found the Osler anemometer for recording the direction and pressure of the wind, and the amount of the rainfall (Fig. 2). The latter we have described in speaking of the rain gauges generally. It is interesting to enter the little turret in which is the recording table carrying forward a sheet of paper moved by clockwork, and to watch the ever-moving pencils writing down at each moment the direction and force of the wind, whether it is a mere breeze or a fierce gale, a zephyr, or a hurricane. The time scale usually employed is about half an inch to an hour, but an arrangement now exists by which, on a gale of wind springing up, the scale can be at once increased to twenty-four times this amount, thus giving much more minute information in regard to the variations of direction and pressure at such times. This anemometer has been at work since the year 1841. At a later date a Robinson anemometer for registration of wind velocity was added. It sometimes happens that the wind force is registered in an unpleasant way at Greenwich as elsewhere, by accident, and I show you a picture of the shutter of the observatory dome which was brought down by a gale on December 22, 1894. The pressure of the wind measured at the time was 27½ lbs. per square foot, and the observer inside the building narrowly escaped being struck by the suddenly released counterweight used to balance the shutter. Mr. Nash has favoured me with these particulars.

We should refer to the matter of the registration of atmospheric electricity. For this the electrometer is employed, as designed by Lord Kelvin (perhaps better known as Sir William Thomson). It is placed in the principal room of the magnetic building, and consists of a carefully insulated cistern which is in communication with the electrometer, and from which, by means of a pipe passing out into the open air, a small jet of water is projected into the atmosphere. The electric potential of this point is thus communicated to the electrometer and recorded by a photographic arrangement on a revolving cylinder. In fine weather the electricity is usually positive in the air, as compared with the earth, but in rainy weather, or in thunderstorms, rapid variations from positive to negative, and back again, are experienced.

Going now to the basement of the building we find the apparatus devoted to the registration of the delicate movements of magnets, made of hardened steel and delicately suspended by long silk filaments, or moving on fine knife edges. Each magnet carries a small mirror so arranged as to reflect a spot of light from a lamp on to a piece of sensitive paper, placed on a cylinder turned round by clockwork, so that every

variation or tremor of the magnets is recorded by a corresponding varying line on the moving paper, making waves of more or less steepness thereon, according to the amount of movement.

When there is no movement or disturbance the line is straight, but this is not the usual state of things. It is scarcely necessary to remind you that any vibration, as from an earthquake shock, may also disturb the magnets mechanically, but earthquakes are rare in this country, and it has not been thought necessary to set up special apparatus more particularly designed for the registration of such phenomena. On February 23, 1887, I find from the Astronomer-Royal's Report the vibration caused by an earthquake as far distant as the south of France caused a disturbance of the magnet corresponding to 20′ of arc in declination, and ·004 of horizontal force, being $\frac{1}{250}$th of the whole horizontal force.

There is also the earth current apparatus for registration of the galvanic currents, that, to a lesser or greater extent, are always present in the earth. Two wires, each several miles in length, and both having earth plates at the two ends of the line, are placed in communication with galvanometers, one to each circuit, each galvanometer carrying a mirror for photographic registration of the variation of earth current force on one cylinder placed between the two galvanometers. Since the end of the year 1890 these records have been greatly disturbed during the day by the trains running on the City and South London Electric Railway, although the nearest earth plate of the system is distant some 2½ miles from the railway.

As a concluding remark we may mention that the time scales of all the records throughout the observatory, both magnetical and meteorological, are, with one exception, identical in length, which much facilitates any collation of the various registers. The one unavoidable exception is the sunshine record, which has a somewhat more extended scale. Those similar in length number in all thirteen.

I have given these somewhat minute particulars of the work done at Greenwich to serve as an example of that which goes on at all observatories of the first order throughout the world, varying a little under special circumstances, but in principle the same, though not always comprising so many subjects of research as pursued in our own Royal Observatory.

It must not, however, be imagined that I have enumerated all the various researches now going on there, work which is forming a firm foundation for the wider meteorology of the future.

Kew Observatory.

Greenwich, is however, not the only Observatory in the vicinity of London, the other is the establishment of the Kew Observatory, which, although known by that name, is really to be found in the Old Deer Park at Richmond, on a small eminence of made ground surrounded by flat park land, and situated a few hundred yards south of the river Thames. The site was occupied during many centuries by an old Carthusian monastery, which was suppressed in 1541. The present building dates from about 1769, when George III. erected it, after the designs of Sir William Chambers, to whom we owe also our Somerset House.

The building then became known by the name of the King's Observatory at Kew, though sometimes more correctly called the Royal Observatory at *Richmond.* George III. provided the establishment with the best clocks and watches that could be obtained at the time, and he often visited the place, while his children frequently attended lectures given there. Our esteemed past President, Mr. R. H. Scott, was from 1871 to 1876 its Honorary Secretary, and from his interesting "History of the Kew Observatory"[1] I have gleaned the foregoing particulars.

About the year 1840 the Government came to the decision that the establishment should be abolished as an astronomical observatory, and

FIG. 3.—Kew Observatory, Richmond, Surrey.

the building was finally handed over to the British Association in 1842. The first resolution of the General Committee of that body at the Manchester meeting in June of that year with reference to their new acquisition, was: "That Prof. Wheatstone, Prof. Daniell, and Mr. Snow Harris be a Committee for constructing a self-recording meteorological apparatus to be employed in the building at Kew."

In the next year the name of Mr. (afterwards Sir Francis) Ronalds, F.R.S., first appeared in connection with the establishment. At the meeting of the British Association at Cambridge in 1845 a conference was held in connection with a committee which had been appointed to "conduct the co-operation of the British Association in the system of simultaneous magnetical and meteorological observations." This conference, among its recommendations, expressed the wish "that it is very

[1] *Proceedings of the Royal Society*, vol. xxxix. p. 37.

highly important that self-recording meteorological instruments should be improved to such a degree as to enable a considerable portion of the observing staff of an observatory to be dispensed with."[1] This suggestion attracted the notice of two eminent scientific inventors, one—Mr. Charles Brooke, F.R.S., who was my predecessor in this chair in the years 1865-6, the other, Mr. Ronalds, at the time on the staff of the observatory of the British Association at Kew, and who became subsequently its superintendent. Both gentlemen completed their inventions of self-recording magnetographs and meteorographs, the Brooke system was adopted by Sir G. Airy at Greenwich, the Ronalds system at Kew. At the date of the reorganisation of the Meteorological Department of the Board of Trade, under a Committee of the Royal Society, the Ronalds system of photographic barographs and thermographs was adopted for all their observatories, and Kew was constituted their central and normal observatory.

The verification branch of the observatory was first set on foot in connection with magnetic apparatus, and subsequently extended to meteorological and other instruments in the early fifties.

A walk through the building enables one to form but a very dim estimate of the work carried on there, but by the kindness of Dr. Chree, the superintendent, I have recently had the opportunity of visiting the place under favourable auspices.

As regards meteorology the institution is of incalculable value, for it is here that all English thermometers, with any pretensions to accuracy, are sent for examination and certificate. After being carefully compared with a standard in hot water, which is contained in a cistern with a transparent side, and also after being submitted to freezing and boiling temperatures, where necessary, the thermometers, if found correct, are marked by etching the "KO" monogram on the glass, and are sent out to the world with an established character for accuracy. Barometers, hydrometers, and other instruments are also severely tested, examined, and marked at Kew, while watches and chronometers, after having been duly baked, frozen, tried in various positions, and carefully timed for months, are sent out with a certificate of the number of marks attained in the competition—100 would mean perfection, and the highest in 1884 reached 88·8. The Kew certificate adds considerably to the selling price of any instrument or watch. Photographic lenses are also examined and certified here, and recently a department has been established for the testing of platinum thermometers, a form of instrument which, though of little use to the meteorologist, is essential to the chemist or metallurgist who has to deal with very high temperatures.

It is at this observatory that the researches into the heights of the various forms of clouds were carried out by the late Mr. Whipple, whom we all so well remember. I show you a photograph of the apparatus he employed, and merely say in passing that the same cloud was, at the same instant, observed by two telescopes, one of which was at the observatory, and the other one some distance away in the park. A triangle could thus be constructed on a known base and with two known angles, so that the cloud height could be calculated with sufficient accuracy. Here is found also a glycerine barometer, in which glycerine is used instead of mercury, and it has in consequence a tube which is as many times the length of an

[1] *Report of the British Association*, 1845, p. 71.

ordinary barometer as the number of times mercury is heavier than glycerine. This results in an instrument over 30 feet in height, and with a much extended scale, so that it is easy to study by its means all the smaller changes in the density of the air, the surface of the coloured liquid in the tube moving under our eyes with unusual disturbances. Magnetic observations are also made here, much in the same way as those already described, in the Royal Observatory, Greenwich, so that the two sets of observations usually check each other. Most of us remember the weekly weather curves published in the *Times*, but now unfortunately discontinued. These emanated from the Kew Observatory.

There are now meteorological observatories in all civilised countries, but the rough sketch I have given of these two of our own will enable one to form some idea of the subjects investigated and the instrumental means adopted.

High Level Observatories.

Let us now turn our attention to those observatories which are situated on the summits of mountains, and which by reason of their altitude attack the problems of air study from a much higher point of vantage. It must be clear to any person who has looked attentively at the sky that the motions of the upper air as shown by its clouds are very different to those of lower levels, and it is with a view of eliminating, as far as possible, the effects caused by inequalities of the ground by friction and by local circumstances, that mountain peaks have in various countries been fixed on for the establishment of meteorological observatories.

Mont Blanc Observatory.

To begin with the highest in Europe I must take you in imagination to Mont Blanc, which, as you know, is situated in France, and about 40 miles to the south of the Lake of Geneva.

In 1887 Monsieur Joseph Vallot ascended Mont Blanc and made some preliminary studies on the summit, leaving some self-registering instruments there during the summer; and it was then that he formed the idea of erecting a permanent observatory on the mountain.

There were many difficulties owing to the great number and variety of the instruments which modern meteorological science demands, and M. Vallot instances that Saussure, in his famous early ascent (in 1787), contented himself with proving that carbonic acid existed in the air at these heights. *Now* it would be necessary to measure the exact *quantity*. M. Vallot pitched his tent at first on the summit, 15,781 feet above the sea, but afterwards, on a more careful survey in 1889, finally decided to place his building on the rocks called Les Bosses, about 1400 feet below the actual summit. He did this for two reasons, the first being that he was afraid of movement if he erected his observatory on the cap of snow, which is really *nevé* covering the summit, the second that it seemed to him the highest spot where he could find a rocky foundation of sufficient size. In addition to these reasons a resting place and shelter were much needed by those overtaken by bad weather in making the ascent, and this latter consideration induced the guides and others in Chamounix, not only to bear a large portion of the expense, but to carry up free of cost the various materials and instruments for the building.

In the summer of 1890 M. Vallot collected his materials and got them successfully transported to the "Bosses" rock, where he put up a tent for the workmen and another for himself. He suffered much from mountain sickness, but he had provided himself with a remedy in a steel tube full of compressed oxygen, of which he breathed several quarts, and then found himself with an appetite for food, and all was well. A storm came on, but by extreme exertion the workmen managed to put up the walls in one day, although at last it was so cold that they could scarcely work even in thick woollen gloves. Of course the porters had brought their burdens up as they best could, and M. Vallot says that by an unhappy fate all the useless things arrived first, and he sought in vain for the means of making a cup of coffee, though he was abundantly supplied with thermometers and other apparatus. For want of a coffee mill they spread the grains of coffee on a little table and ground them to powder by means of an empty bottle. He says that on this table were emptied coffee, soup, petroleum, and other things, so that to this day he does not know what mixture he then swallowed. They spent some fearfully cold nights, and some of the workmen fell ill, and M. Vallot had to revive them by giving them some of his compressed oxygen to breathe.

By the third day they got the roof on, and lit a triumphal bonfire at night to tell the folks at Chamounix that the enterprise was a success.

M. Vallot recounts how in the dead of night, to his great surprise, he heard violent knockings at his door, and on answering them he found some of his porters, who had ascended with lanterns, to inform him that two of his scientific friends were ill with mountain sickness and sunstroke at the Grands Mulets rocks, 3000 feet below.

He tells us that he immediately got up, filled an indiarubber bag with three litres of oxygen, and descending to the Grands Mulets in one hour (though it had taken them six hours to ascend), he arrived at the cabin, gave his friend the oxygen gas, which enabled him to descend with a firm step to Chamounix.

Here M. Vallot found many of his packages detained, and after a successful forage amongst them says he emerged, brandishing as trophies a sphygmograph, a coffee mill, and a broom, the two latter things being much wanted at the summit, to which they returned the same day in scorching sunshine. The whole narrative, as told by M. Vallot, is instructive as well as amusing.

On his next ascent he was accompanied by our esteemed Fellow, Mr. Rotch (of Blue Hill Observatory, Boston, U.S.) who at once commenced some important experiments on sunlight. M. Vallot has ascended many times, and he has published in his interesting *Annals* the scientific results of his observations. No one passes the winter on Mont Blanc, though M. Vallot has had an earnest letter from a lady, who says she is fond of solitude, and who wishes to pass the winter there in making observations.

The observatory contains various rooms for beds and a saloon for the guides, a spectroscopic and photographic observatory, a laboratory, a kitchen, and a room for the self-registering instruments. It is available for students of all nations, and already it has been utilised by observers, there having been in 1893 four French scientific visitors, three Swiss, one German, one Italian, and one American. It is curious that our nation has not been among the first to make use of this building

nobly and gratuitously placed at their service by the heroic founder, who as soon as he knew I was about to read this paper sent me the photographs you have seen and the following letter, a translation of which will be interesting to you all:—

January 2, 1896.

My first scientific expedition to the summit of Mont Blanc was in 1887, and some of the observations then taken are published in my *Annals of the Observatory*.

In 1890 I constructed the observatory on the "Bosses" rock at 4365 metres altitude. Higher than this the summit is capped by a glacier, except where a few rocky points emerge from the surface, but which are too small to build upon.

No one lives in the observatory. During the summer only the self-registering instruments are attended to about every fifteen days. I have no experience of the winter there, but I have devoted three summers (1890 to 1893) to observations which will be published in my *Annals* (vol. ii.) sometime during this winter.

In 1893 M. Janssen, having announced that he was about to establish continuous observations, I ceased this class of work, so as not to do it twice over, and I am now devoting myself above all to the study of terrestrial physics ; and I hope during this winter to publish my works on actinometry, on atmospheric whirls, on storm clouds, and on the transformation of snow into glacier ice.

Besides the observatory on the summit, I have two meteorological stations, one on the Grands Mulets rocks at 3000 metres, and the other at Chamounix at 1000 metres, elevation. The last only is in constant use, the others are put in action when desired, and, as I have said, the four summers' observations that I already possess will suffice to give us some knowledge of the march of the ordinary phenomena of the air at such elevations.

In the summer I reside at Chamounix, and from time to time I go up to the observatory—about once a week at least,—and I have thus made already twenty-one ascents of Mont Blanc. When at the observatory I do my work as much on the actual snowy summit—which is quite near—as in the study which I have built. Life is not easy at these heights, for one has to contend with mountain sickness, but I have become so accustomed to the conditions that I can work there as well as when below, even when there are storms going on during the day or night.

Some few scientific men have also made use of the observatory, but at rare intervals.

After I had constructed my observatory, M. Janssen came there and worked, but he wished to make another of his own, and he placed it on the actual snowy summit of the mountain. He began in 1893 and continued during 1894 and 1895. It is nearly finished, but not yet completely furnished with instruments, so that up to the present no scientific work has been done. M. Janssen has abandoned the idea of permanently entertaining observers there. He has had constructed a superb meteorograph, which has this season been safely placed on the summit.

Unfortunately his observatory is placed *on the snow*, and has therefore no stability, for snow has continual movements of its own, and the clocks of the instruments are stopped. They have seldom gone for more than three days at a time. M. Janssen is very much disappointed, but he has told me that he intends to try other means. It will thus be some time before this observatory can give any results.

From an astronomical point of view, not much further progress has been made. The workmen who ascended to erect the telescope were too unwell to

do the work. Two astronomical expeditions have not been any more fortunate, for the leaders of the same were seized with illness, and could do nothing, although they "saved the situation" by working at the lower level of 3000 metres at the "Grands Mulets" rocks.

To do any work at the summit it is necessary to have been accustomed to exist at great elevations.

I am happy to be of any use to you, and I am desirous to see some English students working in my observatory. I offer my services to you and to your Society, as it is my principle, not solely to work for myself, but to facilitate the labours of others by all possible means.—Yours, etc. JOSEPH VALLOT.

In his *Annals*, M. Vallot further says on the subject of establishing observatories on such elevated spots:—

It is necessary to have been half-blinded by the snow, to have felt the thousand stingings of the atmospheric electricity, to have crawled prostrate over the soft snow, to have been blown over by the wind, and to have crouched down before avalanches, ere one can give a correct account of the terrible intensity of the weather conditions at these great altitudes. It is after this that we comprehend the powerful impulses given to the upper regions of the air, and which are only feebly transmitted to the lower levels through an enormous mattress of atmosphere and vapour which serves to deaden its movements and falsify its indications.

Among the results already to be mentioned as coming from the Mont Blanc observations the following may be here enumerated, though a much longer list might be made.

The wave of diurnal variation of temperature is about one third of the amplitude of that at Chamounix.

The experiences at the Mont Blanc Observatory confirm those of Mr. James Glaisher made in balloon ascents, the cold increases very regularly at the rate of about 1° C. for each rise of 200 metres, which corresponds to 1° F. to 364 feet rise.

The temperature of the air on mountain slopes is sensibly less than in a free stratum of air at the same altitude as observed from a balloon. M. Vallot has given in his *Annals*, as far as possible, all the results as regards air-pressure, moisture, temperature, wind and weather generally, and he must be regarded as having made already, by the publication of his first volume, a real contribution to knowledge in a direction in which comparatively little has been done.

I must not leave the summit of Mont Blanc without showing you the observing cabin which has been gallantly pitched by M. Janssen on the very summit of the mountain, considerably higher, as you will have seen by the photograph, than the more permanent observatory of M. Vallot. The snow movements have for the present defeated M. Janssen, but it is not likely he will give up the attempt. M. Eiffel has also made an observing tunnel or gallery in the ice cap, and sundry timbers and objects placed therein will in the nature of things slowly sink with the glacier, and perhaps inform future ages of what has been done.

European Mountain Observatories.

Time will not permit me to describe to you the other mountain observatories of Europe. There are many, from the Sonnblick in the

Austrian Alps, where there is a well-found observatory at a height of over 10,000 feet, to the establishment on our own Ben Nevis, which only boasts the modest altitude of 4406 feet.

I show you a few pictures representing this last-named observatory and its condition in mid-winter, when I think no one will envy the unfortunate observers who have to stay there, left severely alone.

American Mountain Observatories.

This subject must not be quitted without mention of the observatory which has been perched on the Andes by the enterprise of the authorities of Harvard College in America.

I show you two views of this, by the kindness of Prof. Pickering. One shows the Arequipa station of the observatory at an altitude of 8000 feet, while the other gives a view of the summit of El Misti in Peru, with the meteorological shelters erected there for the accommodation of the self-registering instruments, at the height of 19,200 feet above the sea, constituting this the highest meteorological station in the world.

Most interesting results cannot fail to arise from this gallant attempt to pierce the clouds in search of knowledge. Mr. A. L. Rotch, of the Blue Hill Observatory, Boston, U.S., has constituted himself the authority on high level observatories, and I can refer the Fellows with confidence to his many works, which will all be found in our library.

I must, however, show you one view of the Pike's Peak Mountain in Colorado, and I do this partly because in it Mr. Cohen has caught a very happy effect of cloud. The mountain is over 14,000 feet in height, and although on the south side it is approached by a gentle slope, yet on a nearer view from the east or west sides would be found to be intersected by deep gorges with precipitous walls 2000 feet in height. On the observatory which surmounts Pike's Peak a wind velocity of 92 miles an hour was registered in December 1892.

I also show you views of the observatory on the Brocken Mountain, and that of the Deutsche Seewarte at Hamburg, which latter enjoys the distinction of being the largest meteorological observatory in the world.

Eiffel Tower, Paris.

From mountains to towers is a long step downwards, and I must ask you for a moment to listen to a few particulars about the observations taken on the Eiffel Tower in Paris, of which I show you a photograph, and I should have been glad to give you a nearer view of the meteorological appliances on the top, but, up to the present, it has been found impossible to get a satisfactory photograph of them on account of their elevated position.

On the top of the Eiffel Tower is a self-registering barometer, while in the Bureau Central Météorologique in the Rue de l'Université, there is another, its exact counterpart, and it has been noticed that the first diurnal minimum of air pressure at 4 to 5 in the morning is much more evident at the top of the tower than at the base, while the first maximum at 9 or 10 in the morning is a good deal less marked on the summit than below. The second minimum of 14h. to 17h.—2 to 5 in the afternoon—is also less on the summit; the second maximum at 22h. (10 in the evening) is sometimes

a little more pronounced at the summit, but the difference is slight. The general corrected average pressure throughout the year at the top of the tower is lower by ·12 millimetres, about $\frac{4}{1000}$ of an inch, a difference not yet satisfactorily explained.

As to temperature, it is generally from 1° to 4° C. colder on the tower than below, the month of December being the only one where the temperature is higher at the summit than at the base. The changes of temperature are less regular, the diurnal variations not so large, while the smaller oscillations are much more marked at the summit than at the base, it often happening that some are registered above which are absolutely inappreciable below. Some of the changes of temperature recorded in the tower are very remarkable, as for instance a leap upwards of 10° C. (18° F.), which rise of temperature took two days to communicate itself to the stratum of air below.

All this and much more of great interest to the weather student may be found in M. Angot's masterly *Annals*, 1889 to 1892; and I have been favoured by that gentleman with a letter giving some of his most recent results. It concludes as follows:—

The only general result which is not to be yet found in my annual memoirs is the following:—

The annual variation of temperature on the summit is already found to be very different from that at the level of the soil. The difference of temperature between the lower level and the upper amounts to 1°·6 C. (2°·9 F.) at its maximum at the end of June, while it is at a minimum at the end of September, when it only attains 0°·3 C. (0°·5 F.). The annual cooling of the air occurs much more rapidly below than in the upper air, a fact altogether analogous to that shown by the variation of the daily wave of temperature, and it frequently happens that in the months of September and October there is a mean temperature higher, in absolute value, at 300 metres altitude than on the ground. The inversion, therefore, which is constantly shown in the hourly means, presents itself also in the monthly ones, but only in the autumn, and not in the coldest part of the year.

The Society will be grateful to M. Angot for this preliminary note of some of his important conclusions.

M. Angot also calls attention to the following fact with respect to humidity:—

Sometimes a process, the reverse of evaporation, has been noticed on the Eiffel Tower. After a cold period on one occasion, when a sudden warming of the air took place, accompanied by great humidity, water rapidly condensed from the atmosphere, so that in three days as much as 9 millimetres (about $\frac{3}{8}$ of an inch) accumulated in the vessels used for evaporation experiments. Generally speaking, the atmosphere is nearly 8 per cent drier at the top of the tower than it is below.

Attempts have been made in our own country to secure observations on high towers, but as they have been of necessity confined to much lower altitudes, I must content myself with showing you the pictures of the places where the two most notable experiments have been made, viz. Lincoln Cathedral and Boston Church Tower.

Private Observing Stations.

One word about private observing stations. In addition to the telegraphic reporting stations of the Government this Society has a great

number of observers in different parts of the British Isles, whose daily observations are published in our *Meteorological Record.* I show you a view of such a private installation, and in it you may recognise Mr. Mawley, a gentleman of whom you will know more by and by. Mr. Symons tells me that Mr. Mawley's station is so well arranged and conducted as to serve as a type and pattern for all others of the same order.

Conclusion.

I have now endeavoured, as much as has been possible in one brief discourse, to give you some bare information as to observatories in our own and in foreign countries, and it may be permitted to throw a glance from "the mind's eye" into the future and imagine an observatory in Great Britain which shall more than rival those of other countries. One can figure to one's self a tower piercing the sky from any of the elevated table-lands of this island, Salisbury Plain, the Stray at Harrogate, or anywhere on the Downs between Guildford and Dorking, from which the most interesting results could not fail to accrue. It is the opinion of M. Vallot—no mean authority—that a high tower is for air-observing purposes, equivalent to a mountain station of ten times the altitude, and this is evident when one considers that any mountain must act as an obstacle which thrusts the layers of the atmosphere upwards into a contour almost like its own; so that some of the effects are very little different from those observed below. A tower like the Eiffel Tower, on the contrary, thrusts itself into the air without impeding its movements.

Among the new subjects which might with advantage be studied from such an observatory are the systematic photography of the clouds all round the horizon, and the effects of observed refraction in the different air strata, a subject only yet in its infancy, for Mr. H. F. Newall showed only last Friday to the Fellows of the Royal Astronomical Society how he had observed, in the great telescope at Cambridge, waves of a varying speed and frequency crossing each other at different angles in the field of view, when the telescope was pointed at the open sky. He says these belong to the upper air 4 or 5 miles from the earth, and if he is right (which I hope) here alone is a new field of study which may be fruitful of results in the future.[1]

It is the boast of our Society that it is covering the face of the country, and indeed of the world, with a network of private observing stations, and it is collecting together for the enlightenment of all future time a mass of accurate knowledge on the subject of the thousand changes in our atmosphere, its varying moods, its beating pulses, its calms and its convulsions, so that when the philosopher is born who is destined to unravel all its mysteries, he will find the means and instruments made ready to his hand.

I have to thank many kind friends for the different illustrations I have put before you—Mr. J. G. Wood, Mr. Scott, Mr. Ellis, Dr. Mill, Mr. Rotch, M. Vallot, Mr. Symons, M. Angot, Dr. Chree, and Mr. Edney are all heartily thanked for their kind assistance in the matter.

[1] *The Observatory*, 1896, p. 77.

REPORT OF THE COUNCIL

FOR THE YEAR 1895.

IN presenting their Report the Council have to congratulate the Society on having held its own during the year, the number of Fellows being well maintained, while the finances of the Society remain in a satisfactory condition.

Committees.—The Council have been materially assisted by several Committees, which have been constituted as follows:—

EDITING COMMITTEE.—The President, Rear-Admiral Maclear, and Mr. Scott.

FOG COMMITTEE.—The President, Secretaries, Foreign Secretary, Messrs. Ellis, Russell, and Williams.

GENERAL PURPOSES COMMITTEE.—The President, Secretaries, Foreign Secretary, Treasurer, Messrs. Brewin, Ellis, Latham, Mawley, and Williams.

LECTURE COMMITTEE.—The President, Secretaries, Foreign Secretary, and Mr. Dines.

WIND FORCE COMMITTEE.—The President, Secretaries, Foreign Secretary, Messrs. Chatterton, Curtis, Dines, C. Harding, and Munro.

Lecture.—In consequence of the premises of the Institution of Civil Engineers not having been available for an exhibition, a lecture, in lieu thereof, was delivered on March 20th by Mr. W. N. Shaw, F.R.S. The subject was "The Motion of Clouds considered with reference to their mode of formation." This lecture, which was illustrated by experiments, was appreciated by the large audience present on the occasion, and is printed in the *Quarterly Journal.*

Stations.—Observations have been accepted from the following new stations:—Ely, Cambridgeshire; Woolacombe, North Devon; Wellington, Somerset; and Bridgend, Glamorganshire. The observations have been discontinued at Taunton, North Thoresby, and Windermere. Copies of detailed returns for certain stations and annual summaries of results for others have been supplied, as usual, to the Meteorological Office.

Inspection of Stations.—All the stations south of latitude 54° N. and west of longitude 2° W., as well as such new stations as could be conveniently visited, have been inspected, and found, on the whole, in a satisfactory condition. Mr. Marriott's Report is given in Appendix I., p. 101.

Research Fund.—The Council regret that no donations to this fund have been received during the year.

Library.—Considerable additions by presentation and purchase have been made to the Library as well as to the collection of photographs and lantern slides. Of these a list will be found in Appendix IV. and V. p. 111.

Quarterly Journal.—This publication has contained several papers of

considerable interest, particularly those dealing with frost, floods, gales, and sunshine.

Meteorological Record.—This publication has been brought up to June 1895, and is now in the fifteenth year of its existence; the Council are taking steps to ensure its being issued more promptly in 1896.

Phenological Report.—Mr. Mawley's Report on the Phenological Observations for 1894 was read at the February Meeting. It is satisfactory to find that the distribution of observing stations is gradually being improved.

Offices.—The Council regret to announce that the Society's Offices have been scheduled to be taken by Her Majesty's Government. It is as yet too soon to say where suitable accommodation can be found, but the Council hope that the compensation to be awarded will enable the Society to secure new offices in the same neighbourhood.

Place of Meeting.—Consequent on the rebuilding of the premises of the Institution of Civil Engineers, the Council of that body could not exercise their usual hospitality to the Society between March and November. Application was therefore made to the Council of the Surveyors' Institution, who very kindly granted free permission to hold the April, May, and June meetings at their premises, and most cordial thanks are due to them for the use of their rooms.

Hour of Meeting.—The change of hour for the evening meetings to 7·30 seems, on the whole, to have been conducive to the convenience of the Fellows, for the attendance has somewhat increased.

Fellows.—The change in the number of Fellows is exhibited in the following table, which shows a decrease of five during the year :—

Fellows.	Annual.	Life.	Honorary.	Total.
1894, December 31st	409	138	17	564
Since elected . . .	+33	+1	...	+34
Deceased	−2	−2	...	−4
Retired	−26	...	...	−26
Lapsed	−6	...	...	−6
Defaulters	−3	...	...	−3
1895, December 31st	405	137	17	559

Deaths.—The Council have to announce with much regret the deaths of four Fellows. The names are :—

Arthur James Melhuish, F.R.A.S.	elected Jan. 21, 1863.
Thomas Paulin	„ Nov. 19, 1873.
James Sidebottom, J.P.	„ Feb. 18, 1891.
Beauchamp Charles Wainwright	„ Dec. 21, 1881.

APPENDIX I.

INSPECTION OF STATIONS, 1895.

During the present year I have visited all the stations south of lat. 54° N., and west of long. 2° W. These comprised 6 second order and 28 climatological stations. Although at most of them some recommendation was necessary, the stations were generally in a satisfactory condition.

Comparatively few changes had taken place in the zeros of the thermometers, for out of 167 tested only 10 had altered since the previous comparison.

The sunshine recorders were not always in perfect adjustment, the glass ball frequently not being in the centre of the frame. This is readily seen by the burn not running parallel with the edge of the card.

A good many dry and wet bulb thermometers have a piece of wood fastened across the lower part of their scales to hold the tubes in position; and consequently when low temperatures occur, as was the case during last winter, this wood hides the end of the column of mercury, and so it is impossible to get a reading of the thermometer. I have in most cases requested that the wood be either cut through or removed entirely. It would be an advantage if the instrument makers would adopt some other form of mounting the thermometers.

The observations at Princetown were discontinued on February 14th, but no notice of this reached the Society till some months later. I called on the acting Governor of the prison with the view of getting the observations restarted. As the result of the interview one of the warders was recommended as an observer. After a little instruction he appeared competent to undertake the observations, and so I entered into an arrangement with him for him to carry on the observations on the same terms as with the previous observer. On a subsequent visit a few days later I found the warder taking the observations in a very careful manner.

WILLIAM MARRIOTT.

October 15, 1895.

NOTES ON THE STATIONS.

ABERYSTWITH, *July* 22.—The maximum and minimum thermometers were placed against the louvres at the back of the screen, the maximum being at the top. These were both liable to be shaken by the wind, the mercury in the maximum sometimes running up several degrees. I recommended an entire rearrangement of all the thermometers, which the surveyor undertook to carry out from my directions. The instruments are in a very exposed situation in the Castle grounds. I believe the rain gauge cannot collect the proper amount of rain, as the wind must carry the rain over the gauge. I recommended that another rain gauge should be obtained and placed in Dr. Thomas's garden in the town.

ASHBURTON, *August* 19.—There was no change in the zeros of the thermometers. The posts of the thermometer screen had become rotten, and new ones were required. The outer cylinder of the rain gauge was

leaky, and required repairing. Mr. Amery records the visibility of several distant objects, the farthest being the tower near Dartmouth.

BLACKPOOL, *July* 13.—There was no change in the zeros of the thermometers, but the minimum had 0°·5 of spirit at the top of the tube. The thermometer screen required strengthening. A new road is to be made to the east of the Sanatorium, and this may necessitate the moving of the thermometers and rain gauge. The ball of the sunshine recorder was not in the centre of the frame, nor was the slab level. These I readjusted.

BOLTON, *July* 11.—There was no change in the zeros of the thermometers. The screen required painting. The ball of the sunshine recorder was not quite in the centre of the frame. A 4-foot earth thermometer had been added to the equipment since the last inspection. Mr. Midgley has also a 5-inch tin evaporation gauge, which is placed under a louvre cage.

BRAMPFORD SPEKE, *August* 17.—There was no change in the position of the instruments. On comparing the thermometers it was found that the dry had gone up 0°·1.

BUDE, *August* 27.—There was no change in the zeros of the thermometers. I recommended a rearrangement of the thermometers, and also that the screen be painted white. I advised the observer as to the management of the wet bulb in frost, and also as to the measurement of snow.

BURGHILL, *July* 18.—On comparing the thermometers it was found that the minimum had gone down 0°·3. The screen required painting.

CASTLE HILL, *August* 28.—There was no change in the zeros of the thermometers. The tubes of the thermometers required tightening, and the screen to be made firmer.

CHELTENHAM, *August* 29.—There was no change in the zeros of the thermometers, but the minimum had some spirit up the tube. The inside of the screen required cleaning. The trees round the rain gauges make a considerable angle.

CHESTER, *July* 15.—On comparing the thermometers it was found that the minimum had gone down 0°·5. The Rev. J. C. Mitchell has also a Richard self-recording hair hygrometer, a barograph, and a storm rain gauge.

CHURCHSTOKE, *July* 17.—There was no change in the zeros of the thermometers. The screen required painting and also wedging up. The pedestal supporting the sunshine recorder required readjusting, and to be made secure. The late evening sunshine is evidently lost, as the trees to the west make an angle of 10°.

COLWYN BAY, *July* 16.—The Jordan sunshine recorder is exposed on the roof of the house. It is put up and let down through a hole in the roof, which, however, is too small to put the head through. Dr. Lord has also a set of instruments which are placed in an enclosure in a field on the Princess Drive.

CULLOMPTON, *August* 15.—There was no change in the zeros of the thermometers. I recommended that the inside of the screen be

dusted and cleaned, and also that screws be used for suspending the maximum and minimum thermometers. The ball of the sunshine recorder was not in the centre of the frame. This I readjusted.

FALMOUTH, *August* 22.—There was no change in the zeros of the thermometers. Two of the tubes required readjusting, as the divisions on the stem did not agree with those on the scales. The screen required strengthening.

GWERNYFED PARK, *July* 20.—On comparing the thermometers it was found that the dry and wet had gone up 0°·1. The minimum had 1°·3 of spirit up the tube. The muslin was dirty and required changing.

HAVERFORDWEST, *July* 23.—The instruments are placed in a terraced garden on the south side of the High Street. The exposure is good. Dr. Phillips has taken observations for nearly 50 years. He has had a Lawson screen, and still takes the readings of a maximum and minimum in it for comparison with those in the Stevenson screen. The instruments are usually read by Dr. Phillips's assistant, the cloud and wind being taken by his nephew, who also enters them up and keeps the record.

ILFRACOMBE, *August* 27.—The Stevenson screen and Snowdon rain gauge are well exposed in the position described in the *Quarterly Journal*, vol. xx. p. 164. The screen required painting. On comparing the thermometers it was found the dry had gone up 0°·5. It is proposed to discontinue the old screen at the end of the year, and to turn it into a shelter for the use of visitors at the Hotel.

LANCASTER, *July* 12.—There was no change in the zeros of the thermometers. The tube of the maximum was rather loose; this I set right. While I was at the station the screen was moved to another site at about the same elevation. The exposure of the screen and rain gauge is, in my opinion, much too bleak. I therefore recommended that they be removed to a more suitable site. The ball of the sunshine recorder was not in the centre of the frame. The stock of the summer sunshine cards had been exhausted a week or so previously, and the observer was using the winter ones turned upside down. The early morning sunshine before 8 a.m. was therefore lost.

LLANDUDNO, *July* 16.—There was no change in the zeros of the thermometers. The garden in which the instruments are placed has been let to another tenant, so they will have to be moved to a corner where the exposure will be somewhat more confined than that at present. The sunshine recorder had been removed from the pier, and is now in a garden on the Conway shore, where the exposure is very good. The ball was not in the centre of the frame, but I was not able to readjust it, as the slab was screwed so tightly to the post that I could not take it off.

MALVERN, *August* 30.—The instruments are in the same position as at the former inspection. I recommended that the maximum and minimum thermometers should be suspended by screws and made secure against vibration, also that a small board be placed at the bottom of the screw to cut off radiation and reflected heat.

MONMOUTH, *July* 19.—The instruments are on the lawn at the back of the school-house. New buildings are being erected, which will make the exposure very confined. I therefore selected a new site in the kitchen garden.

NEWQUAY, *August* 21.—There was no change in the zeros of the thermometers. The posts of the thermometer screen require strengthening to prevent vibration. The ball of the sunshine recorder was not in the centre of the frame.

NORTHWICH, *July* 17.—The screen required washing and painting. The muslin on the wet bulb was not clean, but hard and thick with incrustation. I impressed upon the observer the necessity of paying greater attention to the wet bulb.

PENZANCE, *August* 23.—The instruments were in the same position as at the last inspection. I recommended that the screen and rain gauge be moved to the middle of the terraced lawn, instead of being so near the sloping bank. The thermometers required rearranging in the screen. The Campbell-Stokes universal recorder was apparently not registering the early and late sunshine. This was due to the ball not being quite in the centre of the frame. I endeavoured to adjust this, but could not get the ball to keep up in position.

PRINCETOWN, *August* 20.—I called on the Deputy-Governor of the prison, and found that the observations had not been carried on since Mr. Durbin left in February. He recommended Mr. E. M. Ellis, one of the warders, as an observer, who I found was willing to take 9 a.m. observations. Evening observations are practically impossible. I gave him instruction in the taking of the observations, and set the instruments in order. I called again at Princetown on August 26th, and found that Mr. Ellis was taking the observations satisfactorily. The only point in which he was not quite clear was as to the reading the barometer. He, however, speedily mastered this after a few minutes' explanation.

ROSS, *July* 19.—The thermometer screen is in a more open situation than formerly. I recommended, however, that more grass be laid down round the screen. The screws holding the maximum and minimum thermometers required to be tightened, so as to make them more secure. I recommended that the top of the tree to the south of the rain gauge be cut off.

ROUSDON, *August* 14.—There was no change in the zeros of the thermometers. I recommended that the thermometer screen be braced up to prevent vibration; and also that a glass vessel with a cap be used for the water receptacle. The ball of the sunshine recorder, which is the universal pattern, was not in the centre of the frame. Mr. Peek has a recording Dines' anemometer mounted on the water tower by the side of the Robinson anemometer. The vane, however, is 6 feet higher than the cups. The instrument works very satisfactorily.

SIDMOUTH, *August* 17.—There was no change in the instruments. The upper part of a large tree was blown off in a gale during the winter, and so the exposure of the rain gauge is more open. The sunshine recorder, which was on the tower of the Knowle Hotel, has been taken down on account of building operations. A new site will have to be found for the instrument.

STOWELL, *August* 13.—There was no change in the thermometers. An acacia tree having grown considerably so as to make a large angle with the rain gauge, I recommended that the upper part of the tree be lopped.

TAVISTOCK, *August* 20.—The instruments were moved to the lawn below the house at the beginning of the year, and as several trees have been taken down the exposure is very good. The garden is at the top of the Bannawell Road, on the northern slope of a valley which descends rapidly to the south-east.

TEIGNMOUTH, *August* 16.—There was no change in the thermometers. The position of the rain gauge is not satisfactory, but it is the best that can be obtained in the garden.

TORQUAY, *August* 16.—The instruments at Cary Green were in good order. The sunshine recorders are on the top of Chapel Hill, and are well exposed. The frame of the Campbell-Stokes recorder required screwing up, as it was somewhat loose. Mr. Chandler has at Chapel Hill a Richard barograph and thermograph, and a Casella recording embossing anemometer, as well as a set of ordinary instruments.

WELLINGTON, *August* 15.—The instruments are in a garden to the south of the church, and on the highest ground in the neighbourhood. The exposure, however, is somewhat confined. The screen was only about 3½ feet above the ground, and had the door opening to the west. I recommended that the screen be raised to 4 feet, with the door opening to the north.

WESTON-SUPER-MARE, *August* 29.—On comparing the thermometers it was found that the maximum had gone up $0^{\circ}\cdot 1$. The minimum had a little spirit at the top of the tube. The screen required painting and strengthening.

WOOLACOMBE, *August* 28.—The instruments are placed in the grounds facing the Woolacombe Hotel. The exposure is very good. Hills extend from north-west through north and east to south, broken only by a valley to the east. The place is open to the sea from south to north-west. On comparing the thermometers it was found that the dry had gone up $0^{\circ}\cdot 2$ and the wet $0^{\circ}\cdot 1$. Mr. Henshall contemplates making this a second order station, and also procuring a sunshine recorder.

APPEN-

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

Balance from 1894		£194 11 5
Subscriptions for 1895	£692 1 6	
Do. former years	52 0 0	
Do. paid in advance	28 0 0	
Life Composition	21 0 0	
Do. —Additional (Mr. R. H. Scott) . .	9 0 0	
Entrance Fees	38 0 0	
		840 1 6
Meteorological Office—Copies of Returns . . .	£100 5 10	
Do. Grant towards Inspection Expenses	25 0 0	
		125 5 10
Dividends on Stock (including £20 : 5 : 8 from New Premises Fund)		95 19 3
Sale of Publications		26 4 5
		£1282 2 5

DIX II.

FOR THE YEAR ENDING DECEMBER 31, 1895.

EXPENDITURE.

Journal, &c.—		
Printing Nos. 93 to 96	£112 1 9	
Illustrations	44 14 0	
Authors' Copies	17 2 6	
Meteorological Record, Nos. 55 to 58	48 16 6	
Registrar-General's Reports	8 8 0	£231 2 9
Printing, &c.—		
General Printing	£20 3 6	
Stationery	19 7 9	
Books and Book-Binding	17 6 1	56 17 4
Office Expenses—		
Salaries	£438 4 10	
Rent and Housekeeper	200 0 0	
Repairs, Coals, &c.	10 19 10	
Postage	46 17 4	
Petty Expenses	18 2 10	
Refreshments at Meetings	14 12 9	
Lecture Expenses	10 10 0	
Subscription returned	2 0 0	741 7 7
Observations—		
Inspection of Stations	£46 3 3	
Observers	10 2 0	
Instruments	1 6 3	57 11 6
Stock—		
Purchase of £90 : 6 : 2, 2½ per cent Annuities		93 0 0
		£1179 19 2
Balance—		
At Bank of England	£99 0 7	
In hands of Assistant-Secretary	3 2 8	102 3 3
		£1282 2 5

Examined, compared with the Vouchers, and found correct,

FREDC. GASTER, } *Auditors.*
M. JACKSON, }

January 8, 1896.

APPENDIX

ASSETS AND LIABILITIES

LIABILITIES.

	£	s.	d.
To Subscriptions paid in advance	£28	0	0
,, Excess of Assets over Liabilities [1]	3092	12	2
	£3120	12	2

[1] This excess is exclusive of the value of the Library and Stock of Publications.

WM. MARRIOTT, *Assistant-Secretary.*

NEW PREMISES FUND,

	£	s.	d.
Amount paid to the Society's Funds towards the increased rent of the New Premises	£20	5	8
Amount invested in purchase of £10 : 4 : 8 South Australian 3½ per cent Inscribed Stock	11	0	0
	£31	5	8

RESEARCH FUND,

	£	s.	d.
Amount invested in purchase of £2 : 16 : 2, 2¾ per cent Consols . .	£3	0	1

II.—Continued.

ON JANUARY 1, 1896.

ASSETS.

By Investment in M. S. and L. R. 4½ per cent Debenture Stock, £800 at 156	£1248 0 0		
,, Investment in N. S. W. 4 per cent Inscribed Stock, £654 : 18s. at 115⅝	755 11 10		
,, Investment in L. & N. W. R. Ordinary Stock, £200 at 186¼	372 10 0		
,, Investment in 2½ per cent Annuities, £231 : 11 : 9 at 103⅝	239 8 1		
		£2615 9 11	
,, Subscriptions unpaid, estimated at	£50 0 0		
,, Entrance Fees unpaid	6 0 0		
,, Interest due on Stock	51 11 5		
		107 11 5	
,, Furniture, Fittings, &c.	£205 3 0		
,, Instruments	90 4 7		
		295 7 7	
,, Cash at Bank of England	£99 0 7		
,, Cash in hands of Assistant-Secretary . . .	3 2 8		
		102 3 3	
		£3120 12 2	

Examined,

January 8, 1896. FREDC. GASTER, M. JACKSON, } *Auditors.*

DECEMBER 31, 1895.

Contributions of Fellows	£11 0 0
Interest received on investment	20 5 8
	£31 5 8

Note.—The Society holds on account of this Fund £1209 : 4 : 10 South Australian 3½ per cent Inscribed Stock.

Examined,

January 8, 1896. FREDC. GASTER, M. JACKSON, } *Auditors.*

DECEMBER 31, 1895.

Interest received on investment	£3 0 1

Note.—The Society holds on account of this Fund £115 : 10 : 7, 2¾ per cent Consols.

Examined,

January 8 1896. FREDC. GASTER, M. JACKSON, } *Auditors.*

APPENDIX III.

OBITUARY NOTICES.

ISAAC BROWN was born at Amwellbury, a farm near Ware in Hertfordshire, in the year 1803. He was a member and minister of the Society of Friends, and throughout his long life showed forth in a remarkable degree some of the old Quaker characteristics of cultivation and refinement of mind, largeness of heart, and gentleness of spirit. These qualities found a fitting sphere in his special vocation of a schoolmaster, first, in his own private school at Hitchin in 1829, at Dorking in 1845, and in later years as Principal of the Friends' Flounder's Institute, which was established in 1848, at Ackworth in Yorkshire, a post which he retained for twenty-two years.

All those who came within the sphere of his influence in this capacity could bear witness to the thoroughness and conscientiousness of his teaching, qualities which naturally belong to a bent of mind turning with pleasure to the fields of science.

It was essentially so in the case of Isaac Brown. Precluded by his life work from making science his distinctive vocation, he gave to his scientific interests a perseverance and accuracy which kept him faithful to and rendered valuable the limited amount of practical work he was able to undertake.

Next to Astronomy, Meteorology, akin, in a measure, in its lines of research, possessed for him special attractions. While at the Flounder's Institute he kept a regular record of rainfall, of maximum and minimum temperature, of hygrometrical changes, and of the barometer, etc., and, for at least part of the time, notes of cloud in its proportional relation to the sky. The hour of observation was 9 a.m.

In 1870, on resigning his appointment at the Institute, he went to Brantholme, Kendal, settling there for the remainder of his life. During this time his meteorological observations were recorded in the Kendal papers, and when himself incapacitated, through failing health, he taught one of his servants to read the thermometer and register the rainfall.

Isaac Brown was twice married, and had six children by his first wife, four of whom survive him.

The shadows of age overtook him without the slightest impairment of intellect, without the smallest lessening of interest in the affairs of others, or of the world he lived in.

Science still possessed the old charm, and many of his most recent letters, written in a fine distinct handwriting, testify to the clearness with which his thoughts followed all modern discoveries and all dawning lights; while the peace of a finished career, of private rather than public interest, possessing no stirring features, but rich in the love of friends, the content of duty done, and the calm of a chastened spirit, made his latter days a fitting sequel to the whole tenor of his long life.

He died on November 3, 1895.

He was elected a Fellow of this Society on June 4, 1850. The very day of the election of our present respected treasurer, Mr. Perigal.

He was also a Fellow of the Royal Astronomical Society for forty-four years.

ARTHUR JAMES MELHUISH was born in London in 1829. In 1853 he married Caroline Powell, of Tiverton, Devonshire, by whom he had seven children—three sons and four daughters. He lived for some years at Blackheath, but came to London in 1863, and resided for many years at 12 York Place, Portman Square (the house formerly occupied by William Pitt). He died at Brondesbury on November 1, 1895.

In 1873 he started, in conjunction with Mr. Alfred Wilcox, the *Church of England Pulpit and Ecclesiastical Review*, which is still carried on, though now in other hands. He was the author of a work on *Mental Analysis*, and of many papers published in various magazines—"The Geology of the Bible," "Truth about Ghosts," "Good Fools," etc.

Mr. Melhuish was for many years Secretary of the Amateur Photographic Society: he was also a Fellow of the Royal Astronomical Society.

He was elected a Fellow of this Society on January 21, 1863.

BEAUCHAMP CHARLES WAINWRIGHT was the eldest son of Charles James Wainwright, of Elmhurst, East Finchley. He was born in London on April 11, 1860, and was educated at Brentford and at University College School, London. He died at Geraldton, Western Australia, after a few days' illness, from influenza and a weak heart, on April 12, 1895.

Mr. Wainwright took an active interest in the welfare of the Society, and on many occasions rendered valuable services at the meetings with his lantern.

He was elected Fellow of this Society on December 21, 1881.

APPENDIX IV.

BOOKS, ETC., PURCHASED DURING THE YEAR 1895.

BARRAL, F. A.—Le climat de Madère et son influence thérapeutique sur la phthisie pulmonaire. Traduit du Portugais, par le Docteur P. Garnier. 8°. (1858.)

BARTHOLINUS, C.—Specimen philosophiæ naturalis, præcipua physices capita exponens. In gratiam Juventutis Academicæ. Accedit de Fontium Fluviorumque Origine ex Pluviis Dissertatio Physica. 12°. (1703.)

BROCKLESBY, J.—Elements of Meteorology, with questions for examination, designed for schools and academies. Second edition. 12°. (1849.)

CLEGHORN, G.—Observations on the epidemical diseases in Minorca, from the year 1744 to 1749. To which is prefixed a short account of the climate, etc., of that island. Third edition. 8°. (1768.)

HEASTIE, A.—A treatise on the nature and causes of the yellow fever. To which is added a series of meteorological tables, kept by the author, showing the medium temperature and general state of the weather throughout the Archipelago and Levant during the years 1825, 1826, 1827 and 1828. 8°. (1830.)

HELLMANN, G.—Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus. No. 4. E. Halley, W. Whiston, J. C. Wilcke, A. von Humboldt, C. Hansteen. Die ältesten Karten der Isogonen, Isoklinen, Isodynamen, 1701, 1721, 1768, 1804, 1825, 1826. Sieben Karten in Lichtdruck mit einer Einleitung. 4°. (1895.)

OFFICIAL YEAR-BOOK OF THE SCIENTIFIC AND LEARNED SOCIETIES of Great Britain and Ireland. 1895. 8°. (1895.)

PARTINGTON, C. F.—A Manual of Natural and Experimental Philosophy. 2 vols. 8°. (1828.)

WHITE, R.—Madeira, its climate and scenery. Second edition. Edited by J. Y. Johnson. 12°. (1857.)

WOODHEAD, G.—Atmosphere: a philosophical work. 8°. (1852.)

LANTERN SLIDES.

Artists' Zigzag Lightning.
Charts of Minimum Temperature during the Frost of January and February 1895 (6 slides).
Coach-and-Six on Ice on the Thames at Oxford, February 1895.
Herschel's Table of the Weather.
Letter of Sir W. Herschel denying prognostications of the weather.
Merryweather's Tempest Prognosticator.
Parliament Street, Ramsey, Isle of Man, after snowstorm, February 1895.
Skating on the Serpentine, February 1895.
Skating on Windermere, February 1895.

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1895.

Presented by Societies, Institutions, etc.

Adelaide Observatory.—Rainfall in South Australia and the Northern Territory, 1893.

Allahabad, Meteorological Office.—Annual Statement of Rainfall in the North-Western Provinces and Oudh, 1894.

Antwerp, Société Royale de Géographie.—Congrès de l'Atmosphère, 1894.

Barbados, Colonial Secretary's Office.—Returns of Rainfall in Barbados, 1895.

Batavia, Magnetical and Meteorological Observatory.—Observations, 1893. —Rainfall in the East Indian Archipelago, 1893.

Berlin, Deutsche Meteorologische Gesellschaft. — Berliner Zweigverein. Zwölftes Vereinsjahr, 1895.—Meteorologische Zeitschrift, Dec. 1894 to Nov. 1895.

Berlin, Gesellschaft für Erdkunde.—Verhandlungen, Band xxi. No. 10 to Band xxii. No. 9.—Zeitschrift, Band xxix. No. 6 to Band xxx. No. 5.

Berlin, Königlich Preussisches Meteorologisches Institut.—Bericht über die Thätigkeit im Jahre 1894.—Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung im Jahren 1891, Heft 3; 1894, Heft 2; 1895, Heft 1.—Ergebnisse der Gewitter-Beobachtungen im Jahre 1891.—Ergebnisse der meteorologischen Beobachtungen in Potsdam 1893-4.—Ergebnisse der Niederschlags-Beobachtungen, 1893.

Bidston, Liverpool Observatory.—Report of the Director of the Observatory, 1894.

Bombay, Meteorological Office.—Brief Sketch of the Meteorology of the Bombay Presidency in 1894-5.

Boston, New England Weather Service.—Annual Summary, 1893.—Bulletin, Nov. 1894 to Oct. 1895.—Observations, 1893.

Bremen, Meteorologische Station.—Ergebnisse der meteorologischen Beobachtungen, 1894.

Brisbane, Chief Weather Bureau.—Observations taken at Meteorological Stations in Queensland, Oct. 1893 to Aug. 1894, and Oct. to Dec. 1894.—Summaries of Rainfall, Oct. 1893 to Dec. 1894.—Weather Charts of Australasia, Feb. to June and Aug. to Sept. 1895.

Brisbane, General Register Office.—Annual Report by the Registrar-General on the Vital Statistics of Queensland, 1894.—Report on the Vital Statistics, Nov. 1894 to Oct. 1895.

Brisbane, Royal Geographical Society of Australasia (Queensland Branch). —Proceedings and Transactions, vol. x. 1894-5.

British New Guinea, Government Secretary's Office.—Dispatch reporting tour of inspection made by His Honour the Administrator of British New Guinea, extending from Manu Manu on the coast of the possession to the Owen Stanley Range in the interior.—Meteorological Observations taken at Daru (Western Division), 1894.—Meteorological Observations taken at Port Moresby, Jan. to June 1894.

Brussels, Académie Royale.—Annuaire, 1894-5.—Bulletins, 3me serie, tome xxvi.-xxix. 1893-5.

Brussels, Observatoire Royale de Belgique.—Annales Observations météorologiques d'Uccle, Aug. and Sept. 1893.—Annuaire, 1895.—Bulletin Météorologique, Dec. 1894 to Nov. 1895.

BUCHAREST, INSTITUTE MÉTÉOROLOGIQUE DE ROUMANIE. — Annales, 1893.— Buletinul Observatiunilor Meteorologice din Romania, Dec. 1894.

BUDAPEST, KONIGL. UNG. CENTRAL-ANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Jahrbuch, 1892.

CAIRO, SOCIÉTÉ KHÉDIVIALE DE GEOGRAPHIE.—Bulletin, 4me série, Nos. 3 to 6.

CALCUTTA, METEOROLOGICAL DEPARTMENT OF THE GOVERNMENT OF INDIA.—Daily Weather Charts of the Indian Monsoon Area, June 16, 1894, to April 22, 1895.—India Daily Weather Reports, Dec. 8, 1894, to Dec. 6, 1895.—Indian Meteorological Memoirs, vol. v. parts iv.-x., vol. vii., parts i.-iv.—Instructions to Observers of the Indian Meteorological Department, by J. Eliot.—Memorandum on the Snowfall in the mountain districts bordering Northern India and the abnormal features of the weather in India during the past five months, with a forecast of the probable character of the South-west Monsoon rains of 1895.—Monthly Weather Review, July 1894 to July 1895.—Rainfall Data of India, 1894.—Registers of original observations, reduced and corrected, July to Dec. 1894.—Report on the Administration of the Meteorological Department of the Government of India, 1894-5.

CARLSRUHE, CENTRALBUREAU FÜR METEOROLOGIE UND HYDROGRAPHIE IM GROSSHERZOGTHUM BADEN. — Die Ergebnisse der meteorologischen Beobachtungen, 1894.—Niederschlagsbeobachtungen im Grossherzogthum Baden, 1888, parts i. and ii.; 1894, part ii.; and 1895, part i.

CHEMNITZ, KONIGL. SÄCHISCHES METEOROLOGISCHES INSTITUT.—Jahrbuch, 1894, 1 Halfte.

COPENHAGEN, DANSKE METEOROLOGISKE INSTITUT. — Bulletin Météorologique du Nord, Dec. 1894 to Nov. 1895.—Meteorologisk Aarbog, 1891, part ii.; 1892, part ii.; and 1894, part iii.

CORDOBA, ACADEMIA NACIONAL DE CIENCIAS. — Boletin, tomo xiv., Entrega 1 and 2.

CRACOW, K. K. STERNWARTE.—Meteorologische Beobachtungen, Aug. 1894 to June 1895.

CROYDON, MICROSCOPICAL AND NATURAL HISTORY CLUB.—Daily Rainfall in the Croydon district, Dec. 1894 to Oct. 1895.

DORPAT (JURJEW), KAISERLICHE LIVLÄNDISCHE GEMEINNÜTZIGE UND ÖKONOMISCHE SOZIETÄT. — Bericht über die Ergebnisse der Beobachtungen an den Regenstationen, 1892-4.

DUBLIN, GENERAL REGISTER OFFICE. — Annual Report of the Registrar-General (Ireland), 1894.—Supplement to the twenty-seventh Report of the Registrar-General.—Weekly Returns of Births and Deaths, 1895.

DUBLIN, ROYAL IRISH ACADEMY.—Proceedings, third series, vol. iii. No. 3.

EDINBURGH, FISHERY BOARD FOR SCOTLAND.—Report, 1894, part i.

EDINBURGH, GENERAL REGISTER OFFICE.—Quarterly Returns of the Births, Marriages, and Deaths, registered in Scotland for the year ending Sept. 30, 1895.

EDINBURGH, ROYAL SCOTTISH GEOGRAPHICAL SOCIETY. — Scottish Geographical Magazine, 1895.

FIUME, I. R. ACCADEMIA DI MARINA.—Meteorological Observations, July 1894 to June 1895.

GENEVA, SOCIÉTÉ DE GÉOGRAPHIE.—Le Globe, tome xxxiv.

GREENWICH, ROYAL OBSERVATORY.—Magnetical and Meteorological Observations, 1892.—Report of the Astronomer Royal to the Board of Visitors, June 1, 1895.

HAMBURG, DEUTSCHE SEEWARTE.—Aus dem Archiv, 1894.—Ergebnisse der meteorologischen Beobachtungen an 10 Stationen II. Ordnung und an 45 Signalstellen, sowie stündliche Aufzeichnungen an 2 Normal-Beobachtungs-Stationen, 1893.—I. Nachtrag zum Katalog der Bibliothek.—Siebzehnter Jahres-Bericht über die Thätigkeit für das Jahr 1894.—Wetterbericht, 1895.

HELSINGFORS, SOCIÉTÉ DE GÉOGRAPHIE DE FINLANDE. — Travaux géographiques exécutés en Finlande.

HONGKONG, OBSERVATORY.—China Coast Meteorological Register, 1894.—Extract of Meteorological Observations, June to Oct. 1895.—Observations and Researches, 1894.

JAMAICA, GOVERNMENT METEOROLOGIST.—Jamaica Rainfall, 1893.—Weather Report, Nov. 1894 to Aug. 1895.

JURJEW (DORPAT), METEOROLOGISCHES OBSERVATORIUM DER KAISERLICHEN UNIVERSITÄT.—Gewitterbeobachtungen angestellt in Liv- und Estland im Jahre 1894.

KAZAN, OBSERVATOIRE MAGNÉTIQUE DE L'UNIVERSITÉ IMPÉRIALE.—Observations, Sept. 1894 to Feb. 1895.

KEW, OBSERVATORY.—Report of the Kew Committee, 1894.

KIEW, OBSERVATOIRE MÉTÉOROLOGIQUE DE L'UNIVERSITÉ. — Observations, Oct. 1893 to March 1895.—Couche de neige de l'année 1893-4 dans le bassin du Dniéper, par Prof. P. Broounof.—Durée de la prise des fleuves et rivières et celle de la couche de

neige en 1893-4, par Prof. P. Broounof.—Materiaux pour l'étude des dépôts du bassin du Dniéper, July to Dec. 1893, par. Prof. P. Broounof.

La Guardia, Observatorio Meteorológico del Colegio de la Compañia de Jesús.—Cuaderno Tercero.

Lansing, Michigan State Board of Health.—Report of the Secretary for the year ending June 30, 1892.—Principal Meteorological Conditions in Michigan, 1892.

Leon, Escuela de Instruccion Secundaria.—Resumen general de las observaciones meteorologicas, 1894.

Lisbon, Academia Real das Sciencias.—Jornal de Sciencias Mathematicas, Physicas, e Naturaes, Nos. 46-48, 1887-8, segunda serie, tomo i.-iii. 1889-95.—Memorias, nova serie, tomo vi. part ii.—Sessão Publica em 17 de Dezembro de 1893.

Lisbon, Sociedade de Geographia.—Boletim, 13a serie, No. 10, to 14a serie, No. 3.

London, British Association for the advancement of Science.—Report, 1894.

London, Colonial Office.—Annual Meteorological Report, Straits Settlements, 1894.—Annual Report on the State of Negri Sembilan, 1893-4, by the Hon. M. Lister.—Annual Report on the State of Perak, 1893, by F. A. Swettenham.—Annual Report of the State of Selangor, 1893, by W. H. Treacher.—Annual Report on the States of Sungei Ujong and Jelebu, 1893-4, by R. N. Bland and the Hon. M. Lister.—Report of a visit to the Cocos-Keeling Islands, 1894, by H. Clifford.

London, General Register Office.—Annual Summary of Births, Deaths, and Causes of Death, in London and other large towns, 1894.—Quarterly Returns of Marriages, Births, and Deaths, for the year ending Sept. 30, 1895.—Weekly Returns of Births and Deaths, 1895.

London, Geological Society.—Quarterly Journal, vol. li. 1895.

London, Institution of Electrical Engineers.—Journal, Nos. 114-118.

London, Junior Engineering Society.—Record of Transactions, vol. iv. 1893-4.

London, Meteorological Office.—Daily Weather Reports 1895.—Hourly Means at the five observatories under the Meteorological Council, 1891.—Meteorological Charts of the Red Sea.—Meteorological Observations at Stations of the Second Order, 1890-1, with Appendix giving results for certain stations for the 15 years 1876-90.—Report of the International Meteorological Committee, Upsala, 1894.—Weekly Weather Report, 1895.—Report of the Meteorological Council to the Royal Society for the year ending March 31, 1894.—Address of Lieut.-Gen. Sabine, the President, delivered at the Anniversary Meeting of the Royal Society, on Nov. 30, 1868.—Askvädren i Finland, 1892-3, af A. F. Sundell.—Bodenphysikalische meteorologische Beobachtungen, mit besonderer Berücksichtigung des Nachtfrostphänomens, von T. Homén.—Bulletins météorologiques publiés par la 6me section de la Société d'encouragement de l'industrie et du commerce à Varsovie, 1892.—Bulletin quotidien de l'Algérie, Dec. 1894 to June 1895, and Aug. to Nov. 1895.—Comparative Rainfall, Colony of the Gambia, 1890-4.—Confronto della Temperatura all' Osservatorio Etneo ed all' Osservatorio di Catania, del A. Ricco è G. Saija.—Die Resultate der meteorologischen Beobachtungen auf der "Petrinwarte" in Prag, von Dr. F. Augustin.—List of Oceanic Depths and Serial Temperature Observations received at the Admiralty during 1888 from H.M. Surveying Ships, etc.—Meteorological Observations taken at Suva, Fiji, 1893-4, by J. D. W. Vaughan.—Meteorological Report for Western Australia, 1891.—Observations Internationales Polaires, 1882-3. Expédition Danoise, Observations faites à Godthaab, tome i. liv. ii.—Osservazioni Puteometriche eseguite nell' Osservatorio di Catania, del A. Ricco ed S. Arcidiacono.—Report of the Royal Cornwall Polytechnic Society, 1894.—Report on the Meteorology of Ceylon, 1894.

London, Physical Society.—Proceedings, 1895.

London, Royal Agricultural Society.—Journal, third series, vol. v. part iv. to vol. vi. part iii.

London Royal Astronomical Society.—Memoirs, vol. li. 1892-5.—Monthly Notices, vol. lv. No. 2 to vol. lvi. No. 1.

London, Royal Botanic Society.—Quarterly Record, 1895.

London, Royal Geographical Society.—Geographical Journal, July to Dec. 1895.

London, Royal Institution of Great Britain.—Proceedings, No. 88.

London, Royal Society.—Proceedings, Nos. 340 to 352.

London, Sanitary Institute.—Journal, vol. xv. part iv. to vol. xvi. part iii.

London, Sixth International Geographical Congress.—Catalogue of Exhibition.

London, Society of Arts.—Journal 1895—Index to vols. xxxi. to xl. (1882-92) of the Journal.

Madras, Meteorological Office.—Daily Weather Charts, April 1894 to Feb. 1895.

MADRID, OBSERVATORIO. — Observaciones Meteorológicas, 1892-3. — Resumen de las observaciones meteorológicas efectuadas en la Peninsula y algunas de sus Islas adyacentes, 1891-2.

MADRID, SOCIEDAD GEOGRAPHICA.—Boletin, tomo xxxvi. No. 11 to tomo xxxvii. No. 6.

MANCHESTER, LITERARY AND PHILOSOPHICAL SOCIETY.—Memoirs and Proceedings, fourth series, vol. viii. No. 4 to vol. xi. No. 6.

MANILA, OBSERVATORIO METEOROLÓGICO.—Baguios ó Tifones de 1894, por El P. José Algué, S.J.—La Seismologia en Filipinas, por el P. M. S. Masó.—La Meteorologica en la Exposición Colombina de Chicago (1893), Memoria escrita por los P. P. F. Faura y J. Algué.—Observaciones verificadas, Nov. and Dec. 1893, and Feb. to Dec. 1894.

MARLBOROUGH, COLLEGE NATURAL HISTORY SOCIETY.—Report 1894.

MAURITIUS, ROYAL ALFRED OBSERVATORY.—Results of Meteorological Observations, 1894.

MELBOURNE, OBSERVATORY.—Record of Results of Observations in Meteorology, Terrestrial Magnetism, etc., April to Dec. 1894.

MEXICO, OBSERVATORIO METEOROLÓGICO CENTRAL.—Boletin Mensual, Jan. to Sept. 1895.—Resumen, Nov. and Dec. 1894.

MILAN, R. OSSERVATORIO ASTRONOMICO DI BRERA.—Osservazioni Meteorologiche, 1894.—Sulla Teoria dei cicloni, Ricerche di L. de Marchi.

MONTEVIDEO, OBSERVATORIO METEOROLÓGICO DEL COLEGIO PIO DE VILLA COLÓN.—Boletin Mensual, Oct. and Dec. 1894.

MONTEVIDEO, SOCIEDAD METEOROLÓGICA URUGUAYA. —Resumen de las observaciones pluviométricas efectuadas en el primer y segundo trimestre, Jan. to June del año de 1895.

MOSCOW, SOCIÉTÉ IMPÉRIALE DES NATURALISTES. — Bulletin, 1894, No. 3, to 1895, No. 2.

MOSCOW, UNIVERSITÉ IMPÉRIALE.—Observations faites à la Station Météorologique, Nov. 1892 to March 1895.

MUNICH, K. B. METEOROLOGISCHE CENTRAL-STATION.—Beobachtungen der meteorologischen Stationen im Kön. Bayern, Jahrgang XVI. Heft 4 to Jahrgang XVII. Heft 2.—Uebersicht über die Witterungsverhältnisse im Kön. Bayern, Nov. 1894 to Oct. 1895.

NATAL, OBSERVATORY.—Report of the Superintendent for the year 1893-4.

NEWHAVEN, CONNECTICUT ACADEMY OF ARTS AND SCIENCES.—Transactions, vol. ix. part ii.

NEWHAVEN, YALE UNIVERSITY OBSERVATORY.—Report 1894-5.

NEW YORK, ACADEMY OF SCIENCES.—Transactions, vol. xiii. 1893-4.

NEW YORK, CENTRAL PARK OBSERVATORY.—Abstracts of Registers from self-recording instruments, Nov. 1894 to Oct. 1895.

O-GYALLA, METEOROLOGISCH-MAGNETISCHES CENTRAL-OBSERVATORIUM.—Beobachtungen, April 1893 to Sept. 1895.

OTTAWA, GEOLOGICAL SURVEY OF CANADA.—Report, vol. vi. 1892-3.—Maps.

PARIS, BUREAU CENTRAL MÉTÉOROLOGIQUE DE FRANCE.—Bulletin International, 1895.

PARIS, SOCIÉTÉ MÉTÉOROLOGIQUE DE FRANCE.—Annuaire, Oct. 1894 to March 1895.

PHILADELPHIA, AMERICAN PHILOSOPHICAL SOCIETY.—Proceedings, Nos. 143, 146, and 147.

POLA, K. K. HYDROGRAPHISCHES AMT.—Meteorologische und magnetische Beobachtungen, Nov. 1894 to Sept. 1895.

PRAGUE, K. K. STERNWARTE.—Magnetische und meteorologische Beobachtungen, 1894.

PUEBLA, OBSERVATORIO METEOROLÓGICO DEL COLEGIO DEL ESTADO. — Resumen correspondiente á cada dia, Jan. 1894 to July 1895.—Resumen general correspondiente al año de 1892 and 1893.

RIO DE JANEIRO, COMMISSÃO GEOGRAPHICA E GEOLOGICA DO ESTADO DE MINAS GERAES.—Boletim, No. 2, Subsidios para o estudo do Clima do Estado de Minas Geraes, por A. de. A. Lacerda.

RIO DE JANEIRO, OBSERVATORY.—Annuario, 1894-5.

ROME, SOCIETÀ SISMOLOGICA ITALIANA.—Bollettino, vol. i. Nos. 1-6.

ROME, SPECOLA VATICANA.—P. Francesco Denza, Cenni Necrologici.

ROME, UFFICIO CENTRALE METEOROLOGICO E GEODINAMICO ITALIANO.—Annali, serie seconda, vol. xii. part ii. 1890.—Rivista Meteorico-Agraria, Anno XVI. 1895, Nos. 8 to 34.

ST. LOUIS, MISSOURI, BOTANICAL GARDEN.—Annual Report, 1895.

ST. PETERSBURG, KAISERL. RUSSISCHE GEOGRAPHISCHE GESELLSCHAFT. — Beobachtungen der russischen Polarstation an der Lenamündung. I. Theil, Astronomische und magnetische Beobachtungen, 1882-4.

St. Petersburg, Kaiserliche Akademie der Wissenschaften.—Repertorium für Meteorologie, Band xvii.

St. Petersburg, Physikalisches Central-Observatorium.—Annalen, 1893, parts i. and ii.—Der jährliche Gang und die Vertheilung der Feuchtigkeit der Luft in Russland nach den Beobachtungen von 1871-90, von A. Kaminskij.

San Fernando, Instituto y Observatorio de Marina.—Anales, sección 2a. Observaciones meteorológicas y magnéticas, 1893.

San José, Instituto Físico-Geográphico Nacional de Costa Rica.—Anales, tomo v. 1892.

San Salvador, Observatorio Astronómico y Meteorológico.—Anales, 1893-4. —Observaciones meteorológicas, Oct. to Dec. 1892. Resumen Anual, 1892.

Silvertown, Indiarubber, Gutta-Percha, and Telegraph Works Company. —Soundings, 1889-94.

Sophia (Bulgaria), Station Centrale Météorologique.—Bulletin mensuel, Dec. 1894 to Nov. 1895.

Southport, Meteorological Department.—Report and Results of Observations, 1894, by J. Baxendell.

Stockholm, Académie Royale des Sciences de Suède.—Nagra anmärkningar om luft-elektricitetens variationer vid barometriska minima och maxima, af S. A. Andrée.—Om yrsnön i de arktiska trakterna, af S. A. Andrée—Meteorologisk dagbok under en resa i Egypten, Arabien och Nubien aren 1836-7, af B. Cronstrand—Iakttagelser rörande klotblixt, af E. Edlung.—Molnens höjd i Upsala under Sommaren, af N. Ekholm och K. L. Hagström.—Om atmosferens höjd vid olika arstider, af H. Gyldén.—La radiation des nuages supérieurs autour des minima barométriques, par H. E. Hamberg.—Nederbördens mängd pa nakna och skogbeväxta asar i norra Halland, af H. E. Hamberg.—Om luftens olika grad af genomskinlighet i Upsala, af H. E. Hamberg.—Ett ovanligare askvädersfenomen, meddelande af H. Hildebrandsson.—Om nederbördens förändringar i Sverige under sommarhalfaret, af S. A. Hjeltström. —Undersökning af nagra felkällor vid nederbördsmatning, af S. A. Hjeltström.—En hypotes om det "Röda skenets" uppkomst, af C. E. af Klercker.—Nagra upplysningar rörande isläggningen vid Sveriges kuster vintern, 1870-71, af C. B. Lilliehöök. —Undersökningar öfver atmosferens kolsyrehalt, af A. Palmqvist.—Om temperatur- och fuktighets-förhallendena i de nedersta luftlagren vid daggens bildande, af R. Rubenson.—Om uppkomsten af ett barometriskt depressions-centrum i det inre af Sverige den 11 Maj 1873, af R. Rubenson.—Finnes, utom dimmor och moln och annan synlig utfällning, flytande eller fruset vatten i atmosferen? af K. H. Sohlberg. —Försök öfver den atmosferiska luftens fuktighet, af K. H. Sohlberg.—Ein neues Hygrometer, von K. Sondén.—Bidrag till kännedomen om vindförhallandena i de Spetsbergen omgifvande delarne af Norra Ishafvet, af A. Wijkander.—Iakttagelser öfver luftelektriciteten under den Svenska polarexpedition 1872-3, af A. Wijkander. —Om norrskenets spektrum, af A. Wijkander.

Stockholm, Meteorologiska Central-Anstalten.—Manadsöfversigt af Vaderleken i Sverige, Nov. 1894 to Oct. 1895.

Strassburg, Leiter des meteorologische Landesdienstes in Elsass-Lothringen.—Ergebnisse der meteorologischen Beobachtungen im Reichsland Elsass-Lothringen, 1893.

Sydney, Observatory.—Meteorological Observations, July 1894 to Feb. 1895.—Results of Rain, River, and Evaporation Observations in New South Wales, 1893.—Weather Charts, 1894.

Sydney, Royal Society of New South Wales.—Journal and Proceedings, vol. xxviii. 1894.

Tacubaya, Observatorio Astronómico Nacional.—Anuario, 1896.—Las Lluvias en Tacubaya, por M. Moreno y Anda.

Tiflis, Physikalische Observatium.—Beobachtungen, 1892-3.—Beobachtungen der Temperatur des Erdbodens, 1888 und 1889.

Tokio, Central Meteorological Observatory.—Annual Report, 1894, part i.

Tokio, Imperial University of Japan.—Calendar, 1894-5.

Toronto, Meteorological Office.—Monthly Weather Review, June 1894 to June 1895.—Toronto General Meteorological Register, 1894.

Trieste, I. R. Osservatorio Astronomico-Meteorologico.—Osservazioni meteorologiche, Aug. 1893 to June 1895.

Trieste, Osservatorio Astronomico-Meteorologico.—Rapporto annuale, 1892.

Turin, Osservatorio della R. Università.—Osservazioni Meteorologiche, 1893-4.—Sui modo di dedurre la media giornaliera della osservazoni meteorologiche fatta a Torino in tempo medio dell' Europa Centrale.

Turin, Società Meteorologica Italiana.—Bollettino Mensuale publicato per cura dell' osservatorio centrale del Real Collegio Carlo Alberto, Dec. 1894 to Nov. 1895.

Upsala, Observatoire Météorologique de l'Université.—Bulletin mensuel, 1894.

UTRECHT, K. NEDERLANDSCH METEOROLOGISCH INSTITUUT.—Meteorologisch Jaarboek voor 1893.—Onweders in Nederland, 1894.

VIENNA, K. K. CENTRALANSTALT FÜR METEOROLOGIE UND ERDMAGNETISMUS.—Beobachtungen, July 1894 to May 1895.

VIENNA, K. K. HYDROGRAPHISCHES CENTRAL-BUREAU.—Jahrbuch, I. Jahrgang 1893.

VIENNA, OESTERREICHISCHE GESELLSCHAFT FÜR METEOROLOGIE.—Meteorologische Zeitschrift, Dec. 1894 to Nov. 1895.

WASHINGTON, UNITED STATES GEOLOGICAL SURVEY.—Annual Report, 1892-3.

WASHINGTON, HYDROGRAPHIC OFFICE.—Pilot Charts of the North Atlantic Ocean, 1895.—Pilot Charts of the North Pacific Ocean, 1895.

WASHINGTON, SMITHSONIAN INSTITUTION.—Report, 1893.

WASHINGTON, WEATHER BUREAU.—Climate and Health, Nos. 1 to 3, July to Aug. 1895.—Monthly Weather Review, Sept. 1894 to June 1895.—Report of the Chief, 1893.—Report of the International Meteorological Congress held at Chicago, Aug. 21-24, 1893, part ii.

WATFORD, HERTFORDSHIRE NATURAL HISTORY SOCIETY.—Transactions, vol. vii., part vii., and vol. viii. parts i.-v.

WELLINGTON COLLEGE, NATURAL HISTORY SOCIETY.—Annual Report, 1894.

WELLINGTON, N. Z., REGISTRAR-GENERAL'S OFFICE—Statistics of the colony of New Zealand, 1893.

ZI-KA-WEI, OBSERVATOIRE MAGNÉTIQUE ET MÉTÉOROLOGIQUE.—Bulletin mensuel, 1893.

ZURICH, SCHWEIZERISCHE METEOROLOGISCHE CENTRAL-ANSTALT.—Annalen, 1893.

PRESENTED BY INDIVIDUALS.

ÅKERBLOM, P.—Sur la distribution à Vienne et à Thorshavn des Éléments météorologiques autour des Minima et des Maxima barométriques.

ANDRÉE, S. A.—Iakttagelser under en Ballongfärd den Feb. 26 ; Apr. 7 ; July 14 ; Aug. 4 ; and Nov. 29, 1894.—Ueber die Kohlensäure der Atmosphäre.

BARNES, Dr. R.—Woodhall Spa.

BAUER, L. A.—Beiträge zur Kenntniss des Wesens der Säcular-Variation des Erdmagnetismus.

BAXENDELL, J.—Meteorological observations at Southport, Dec. 22, 1894, to Dec. 21, 1895.

BAYARD, F. C.—Report of the Meteorological Sub-Committee of the Croydon Microscopical and Natural History Club, 1894.

BELLAMY, F. A.—A discussion of observations of some Migratory Birds in the British Isles.—Phenology, or the Annual Appearance of certain Birds, Flowers of Plants, and Insects.

BOYS, Rev. H. A.—The November Floods, 1894 [in Northamptonshire].

BROWN, A., and BOOBBYER, P.—The Meteorology of Nottingham, 1894.

BUCHAN, Dr. A.—Rainfall of Scotland.—The Physics and Chemistry of the voyage of H.M.S. Challenger. Part viii. Report on Oceanic Circulation.

CHANDLER, A.—Abstract of Meteorological Observations at Torquay, 1894.

CLARK, J. E.—Natural History Journal, 1895.

CLEMENTS, H.—Clerk of the Weather, containing forecasts for April and Sept. 1895.—Forecasts of Atmospheric Pressure, Temperature, Sunshine, Rainfall, Direction and Force of Wind, and Appearances of Sky and Atmosphere for 1895.

CLIFFORD, H.—Annual Report on the State of Pahang, 1894.

COOKE, R.—Rainfall at Detling, Maidstone, 1894 (MS.).

COVENTRY, F.—Results of the Meteorological Observations at Ketton Hall, Stamford, 1894 (MS.).

COXEN, Mrs.—Meteorological Observations made at Bulimba, Queensland, Jan. 1894 to June 1895 (MS.).

CRESSWELL, A.—Records of Meteorological Observations taken at the Observatory of the Birmingham and Midland Institute, July 1893 to Dec. 1894.

DOBSON and BARLOW, Messrs.—Humidity in Cotton Spinning. A paper by B. A. Dobson.

DOYLE, P.—Indian Engineering, vol. xvi. No. 24 to vol. xviii. No. 23.

EATON, H. S.—Dorset Annual Rainfall, 1848-92.

EDITOR.— American Meteorological Journal, 1895.

EDITOR.—Ciel et Terre, 1895.

EDITOR.—Electrical Review, 1895.

EDITOR.—Nature, 1895.

EDITORS.—Observatory, 1895.

FARRAH, J., and WALDBY, J. R.—The Weather in Harrogate, Jan. 1895.

FOREL, F. A.—Les Variations périodiques des Glaciers.

FOX, W. L.—Meteorological and Magnetical Tables and Reports for 1894 at Falmouth Observatory.

FREJLACH, Dr. J.—Intorno all' andamento diurno che ha la frequenza di votazioni del vento nell' intervallo di 4 ore a Praga.—Zur Kenntniss der anemometrischen Verhältnisse von Prag.

GLYDE, E. E.—Abstract of Meteorological Observations taken at Tavistock, Devon, 1894.—Meteorological Summaries at Tavistock, Devon, Nov. 1894 to Oct. 1895.

GREENWOOD, Captain W. N.—Greenwood's Kludonometric Tide Tables, 1895.—Greenwood's Nautical Almanac, 1896.

GROSSMANN, Dr. L.—Die Berechnung der Konstanten der Bessel'schen Formel.—Meteorologische Divisionstafeln.

GUPPY, Dr. H. B.—River Temperature, part ii. The Temperature of the Nile compared with that of other great rivers.

HAMBERG, H. E.—Öfversikt af Sveriges Klimat.

HANN, Dr. J.—Der tägliche Gang des Barometers an heiteren und trüben Tagen, namentlich auf Berggipfeln.—Die Verhältnisse der Luftfeuchtigkeit auf dem Sonnblick-gipfel.

HARRISON, Dr. C.—Annual Report of the Medical Officer of Health and Public Analyst, City of Lincoln, 1893.

HARTL, H.—Meteorologische und magnetische Beobachtungen in Griechenland.

HELLMANN, Dr. G.—Photographien von Schneekrystallen.—Resultäte des Regenmess-Versuchsfeldes bei Berlin, 1885-91.—Zum 250-jährigen Jubiläum des Barometers.

HILDEBRANDSSON, Dr. H.—Wolkenstudien von Clement Ley.

HILL, G. H.—Returns of the Rainfall in the Glasgow, Manchester, Ashton, Dewsbury, Stockport, Halifax, Blackburn, Holme Reservoirs, Oldham and Batley Waterworks Districts, 1894.

HOPKINSON, J.—Climatological Observations taken in Hertfordshire, 1894.—Meteorology of Middlesex and Hertfordshire, Sept. 1894 to Nov. 1895.

HUNTER, J.—Meteorological Observations at Belper, 1895.

KAMMERMANN, A.—Résumé Metéorologique de l'année 1894 pour Genève et le Grand Saint Bernard.—Sur quelques particularités de l'hiver 1894-5.

LAKE, Dr. W. C.—The Frosts of 1855 and 1895, as observed at Teignmouth.

LANCASTER, A.—Congrès de la Science de l'Atmosphère. Anvers, 16-18 Août 1894. Communications faites par A. Lancaster.—La Pluie en Belgique, part i.—Le Climat de la Belgique en 1894.—Sur la périod de Froid du 27 Janvier au 17 Fevrier 1895.

LEYST, E.—Ueber den Magnetismus der Planeten.

MACDOWALL, A. B.—Weather and Disease.

MANSON, M.—Physical and Geological traces of permanent Cyclone Belts.

MARKHAM, C. A.—Meteorological Report for Northamptonshire, Oct. 1894 to Sept. 1895.

MARSHALL, S. A.—Rainfall in the Lake District, Dec. 1894 to Nov. 1895.

MAWLEY, E.—The Rosarian's Year-Book, 1895.

MELLISH, H.—The Weather of 1894 at Hodsock Priory, Worksop.

MORENO Y ANDA, M.—Estudio sobre el Magnetismo terrestre en México.

MOSSMAN, R. C.—Results of the Meteorological Observations taken at Edinburgh, 1894.

NABER, H. A.—Standard Methods in Physics and Electricity criticised.

PARNABY, J. M.—Meteorological Report for Albert Park, Middlesborough, Dec. 1894, Jan., Feb. and Apr. to Nov. 1895 (MS.).

PEEK, C. E.—Meteorological Observations at Rousdon Observatory, Devonshire, 1894.

PRESTON, A. W.—Meteorological Notes, 1894. From observations taken at Brundall, Norfolk.—Notes on the Great Frost of 1894-5.—Notes on the Great Gale of March 24, 1895.

PRIGG, H. V.—Meteorological Report for the Borough of Plymouth, 1894.

PRINCE, C. L.—A literal translation of the Astronomy and Meteorology of Aratus.—A Record of the Great Frost of Jan. and Feb. 1895, contrasted with some observations of other severe frosts which have occurred during the present century.—The summary of a Meteorological Journal kept at Crowborough Hill, Sussex, 1893-4.

PUGA, G. B. Y.—Tempestades del fin del invierno.

RAMSEY, A.—The Scientific Roll, Climate; Baric condition, Nos. 6 and 7.

ROBERTSON, Dr. C.—Is the Earth a planet?

RODGER, J. P.—Annual Report of the State of Selangor, 1894.

ROTCH, A. L.—Meteorological Observatory on Mount Cimone, Italy.—Physiological effects of High Altitudes.—Studies of the Upper Air.—Weather Studies at Blue Hill, by R. L. Bridgman.

SALLE, O.—Das Wetter, 1895.
SANDERSON, T. H.—Résumé Mensuel des Observations Météorologiques faites à l'Observatoire Khédivial du Caire, Aug. to Dec. 1894.
SCHERER, Prof. P. J.—Täglicher Gang des Barometers zu Port au Prince nach zweijährigen Beobachtungen, 1890-92.
SCHLICH, Dr. W.—Manual of Forestry: vol. iii. Forest Management, by W. Schlich; vol. iv. Forest Protection, by W. R. Fisher.
SCHREIBER, Dr. P.—Ueber registrirende Regenmesser und Pegel.
SHEWARD, R.—Annual Report of Meteorological Observations at Eastbourne, 1894.
SLADE, F.—Meteorological Observations at Beckford, Tewkesbury, 1894.
SPIEGELHALTER, E. K.—Climatological Record for 1894, taken at Malton.
SRESNEVSKY, Dr. B.—Théorie de l'hygromètre à cheveu.
STAGGEMEIER, A.—Geographical Positions (charts).
STANLEY, W. F.—Notes on the Nebular Theory.
STOKES, J.—Annual Report of the Medical Officer of Health of the Borough of Margate, 1894, to which is appended the Meteorological Report.
SWETTENHAM, F. A. (C.M.G.)—Annual Report on the State of Perak, 1894.
SYMONS, G. J.—Symons's British Rainfall, 1894.—Symons's Monthly Meteorological Magazine, 1895.
TAYLOR, Captain E. R.—Meteorological Observations at Ardgillan, Balbriggan, 1894.
TAYLOR and FRANCIS, Messrs.—Taylor's Calendar of the Meetings of the Scientific Bodies of London for 1895-6.
TYRER, R.—Meteorology of Cheltenham, 1894.—Rainfall in the County of Gloucester, Dec. 1894 to Nov. 1895.
VEEDER, M. A.—Magnetic Storms and Sunspots.
WARD, R. DE C.—Recent Foreign Studies of Thunderstorms: V. Russia; VI Switzerland.
WHITE, H. E.—Summary of Meteorological Observations at Tangier, Morocco, 1894 (MS.).
WILD, Dr. H.—Das Konstantinow'sche meteorologische und magnetische Observatorium in Pawlowsk (bei St. Petersburg).—Neue Normal-Lufttemperaturen für das russische Reich.
WILMHURST, A. J.—Temperature and Rainfall at Manor Park, Essex, Dec. 1894 to Nov. 1895 (MS.).
WILSON-BARKER, Captain D.—Clouds and Weather.
WOEIKOF, Dr. A.—The Climate of Russia.
WOODD, B. T.—Charts from Richard Barograph at Conyngham Hall, Knaresboro', 1894 (MS.).

PHOTOGRAPHS.

ARCHIBALD, W.—Lightning at Newark, N. J., U. S. A. (2 photos).
COCKERELL and Co., Messrs. G. J.—Ice on the Thames off Charlton, February 1895.
ELLIS, W., F.R.S.—River View, Greenwich, February 1895 (2 photos).
FOWLER, Rev. W. W.—A Frozen Tree. Effect of burst water-pipe, Lincoln, February 1895 (2 photos).
GODBOLD, H. J.—Lightning at Hastings, July 6, 1894.
HILLS and SAUNDERS, Messrs.—Coach-and-six on ice on Thames at Oxford, February 1895.—Roasting of a sheep on ice on the Thames at Oxford, February 1895.
HUNTER, J. J.—Ice on the Derwent at Belper, February 1895 (2 photos).
LEADBEATER, J.—Lightning at Rotherham, June 26, 1895.—Hoar frost on window (4 photos).
MARRIOTT, W.—Ice on the Thames, February 19, 1895 (3 photos).—Ice on lake in St. James's Park, February 28, 1895 (3 photos).
MIDGLEY, W. W.—Hygrophant for use in cotton mills.
SHEPHERD, E. S.—Lightning, May 30, 1895 (3 photos).
STOW, Rev. F. W.—Winter Scenes, Aysgarth, Yorks, February 1895 (12 photos).
WATERS, R.—Skating on Lake Windermere, February 1895 (4 photos).
WESTLAKE, W. G.—Lightning at Sutton, August 22, 1895.
WILSON-BARKER, Captain D.—Ice on the Thames off Greenhithe, February 1895 (7 photos).

LANTERN SLIDES.

MARRIOTT, W.—Ice on the Thames, February 19, 1895 (4 slides).—Ice on lake in St. James' Park, February 28, 1895.—Waterfowl on ice in St. James' Park, February 28, 1895.
PRINCE, C. L.—Ice on the Thames off Charlton, February 1895 (5 slides).—Snow Crystal.
STOW, Rev. F. W.—Aysgarth Force waterfalls during frost of February 1895 (4 slides).

APPENDIX VI.

REPORTS OF OBSERVATORIES, ETC.

THE METEOROLOGICAL OFFICE.—Lieut.-Gen. R. Strachey, R.E., C.S.I., F.R.S., Chairman of Council; Robert H. Scott, M.A., F.R.S., Secretary; Nav. Lieut. C. W. Baillie, F.R.A.S., Marine Superintendent.

MARINE METEOROLOGY.—*Current Charts for all Oceans.*—The Admiralty having undertaken to publish these Charts for the Office, an officer has been detailed by the Hydrographer to aid in generalising the currents for publication. It has been decided to publish Monthly Charts, and not Quarterly only, and a commencement has been made with the Indian Ocean. Seven of the Charts are issued, and the remaining five, completing the year, will follow them without delay. The Atlantic Ocean has next been taken in hand, and the twelve Charts for it may be expected at an early date. As to the Pacific Ocean, the comparative paucity of information for that extensive area renders the task of obtaining a fair representation of its currents a very difficult one.

The Charts of the *Red Sea* have been published, and those for the *Southern Indian Ocean* (from the Cape of Good Hope to New Zealand) are about to be sent to press.

The South Atlantic Ocean.—This work is in a very forward state, and the discussion of the materials for publication will shortly be taken in hand.

Weather Telegraphy.—The only addition to the Reporting Stations during the year has been that the Portuguese Government has kindly forwarded reports from Ponta Delgada in the Azores.

The year 1895 having completed another Lustrum, additional means have been published as an appendix to the Volume for the year, and as to the Volume for 1896, the information given as to means, etc., on the second page, has been largely increased.

British Rain, 1881-90.—The tables for 492 stations forming part i. have been printed, as well as those in part ii., giving for 157 of these stations figures for back lustra, to supplement those given in the earlier similar publication of the Office issued in 1883.

Land Meteorology of the British Isles.—The volumes of *Hourly Mean Readings for Five-day Periods for the Four Observatories* for 1891 and 1892 have both been published, and the volume of *Returns from Stations of the Second Order* for 1891 has appeared. Both these serials are in an advanced stage for the succeeding years in each case.

The two pressure tube anemometers have been erected at Holyhead and Scilly, and their use has already furnished important information as to the effect of exposure on anemometers erected on buildings.—*March* 11, 1896.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

The usual routine meteorological work has been carried out satisfactorily during the past year, though somewhat hampered by the building operations in connection with the extension of the new Physical Observatory, and the erection of the new Altazimuth building. No further change has yet been made in the position of the meteorological instruments, but this is a matter which is under consideration.

Serious interruption to registration was experienced during the severe frost in February, partly on account of failures in the gas supply, but more especially

on account of the freezing of the water-pipes. The inconvenience due to this latter cause was of a very serious nature, for not only were the electrometer records almost entirely lost, but the photographic operations, which require the use of much water, were carried out under very trying and difficult circumstances, and the photographs obtained under these conditions were certainly not of a very high degree of excellence. Another important loss at a critical time during the frost was that of the readings of the earth thermometers, 6 feet and 3 feet deep, which were out of range for 48 and 25 days respectively. The advisability of supplementing the present establishment of earth thermometers with a set of thermometers at lesser depths down to 3 feet is under consideration.

Information relating to the remarkable squall of January 23rd was communicated to Mr. Marriott and embodied by him in a paper presented to the Royal Meteorological Society on February 20th.

The printing of the Meteorological Reductions, 1841-90, has been completed, and the work is now being distributed.

The mean temperature for the year 1895 was 49°·3, which is nearly the same as the 50 years' average. The maximum temperature for the year (87°·3), which occurred on September 24, was the highest temperature which had been experienced at such an advanced time of the year throughout the whole term of observation since 1841. Higher values have been recorded twice only in September, viz. on September 7, 1868, when 92°·1 was recorded, and on September 1, 1886, when the maximum was 87°·7. The lowest temperature for the year, 6°·9, occurred on February 8, during the great frost, and was the lowest recorded in the month of February since the commencement of regular observation in 1841. The lowest value previously recorded in February was 7°·7 on February 12, 1845. The range of temperature in the year was 80°·4. The mean monthly temperature for February was 29°·1, being 10°·4 below the 50 years' average; and the mean for September, 61°·9, was 4°·7 in excess of the average.

Bright sunshine in the year amounted to 1227 hours, which is about 50 hours less than the average value. In May the recorded amount was 203 hours, or a percentage of 42, and in September sunshine was recorded during 195 hours, the percentage being 52.

The rainfall, 19·725 in., is the smallest since 1884, when the fall amounted to 18·05 in. There was great deficiency of rainfall in the months of February, May, June, and September, the total amount for the four months being nearly 6 in. in defect as compared with the average amount.—*April* 2, 1896.

Royal Observatory, Edinburgh.—Ralph Copeland, Ph.D., F.R.S.E., Astronomer Royal for Scotland.

The daily readings of the barometer and thermometers were continued at Calton Hill without interruption until November 9th, when the final move was made to the New Royal Observatory at Blackford Hill; but the daily rain gauge record was carried on to the end of the year, when it was taken up by the city authorities, who have acquired the old Observatory. The weekly readings of the five rock thermometers at Calton Hill have been carried on without break, and will continue to be taken as before by the Royal Observatory staff.

Remarkably low readings of two of these thermometers (35 and 57 in. respectively below the surface of the soil) were recorded during the intense and long continued cold of February 1895, the former having registered 35°, and the latter 36°, on February 25. Such low readings have not been observed since 1886, when the former thermometer read 35°·5, and 1881 when it read 34°·3.

At the new Observatory at Blackford Hill the barograph and barometer,

the thermometers and rain gauges, were all mounted in time to begin a continuous record on January 1, 1896, and a monthly return will be made to the Scottish Meteorological Society. The large Robinson recording anemometer, for direction and velocity of the wind, will shortly be mounted on a lofty iron lattice pillar.—*February* 12, 1896.

KEW OBSERVATORY, RICHMOND, SURREY.—Charles Chree, D.Sc., Superintendent.

The several self-recording instruments for the continuous registration of atmospheric pressure, temperature of air and wet bulb, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year, and the standard eye observations for the control of the automatic records duly registered.

The tabulations of the meteorological traces have been regularly made, and these, as well as the copies of the eye observations, with notes of weather, cloud, and sunshine, have been transmitted, as usual, to the Meteorological Office.

Anemograph.—A considerable number of experiments made to check the correctness of the wind vane by comparison with a flag led to no certain conclusion. It only appeared that if any error existed it must be small.

Electrograph.—The performance of this instrument throughout the year has not been satisfactory. Some 27 days' records were lost in January and February through stoppage by the frost, and for about 45 days in July and August the instrument was out of action. Towards the end of the year the performance was generally unsatisfactory. After a good deal of fruitless investigation as to the causes affecting the scale value, defective insulation in the quadrant electrometer and the water-dropper can, the defect has been traced to a gradual deterioration in the insulation of the wire connecting the can with the electrometer. Action is contemplated which will reduce in future the chance of such a misadventure.

On June 11 the instrument was dismounted, old acid removed, and a new suspension, with almost parallel sides, fitted up in order to widen out the scale. Determinations of the scale value were made on April 5, May 28, June 11, and November 27 by direct comparison with the portable electrometer, White 53.

This latter instrument was sent to White of Glasgow in December 1894, to have a new torsion suspension fitted, and to be generally overhauled. After its return from the maker the value of its scale was kindly determined by Prof. Carey Foster at University College Laboratory, and the mean value for one division found to be 290 volts, and this new value has been employed in obtaining the scale-figures for the self-recording instrument.

Fog and Mist.—The observations of a series of distant objects, referred to in the last Report, have been continued. A note is taken of the most distant of the selected objects which is visible at each observation hour.

Atmospheric Electricity.—The series of eye observations with the portable electrometer at certain points in the neighbourhood of the Observatory commenced last year have been continued. The results arrived at seem interesting in themselves, and are likely to prove of service in interpreting and checking the records obtained with the water-dropper and electrograph.

Aneroid Barometers.—The apparatus referred to in the last Report was delivered by the maker, Mr. J. J. Hicks, early in the year, and a large number of experiments have been made and reduced; the results have not yet been published.

Nocturnal Radiation.—Regular observations of two minimum thermometers freely exposed on grass, having shown that a constant lowering of their zero had been taking place for some years, two other minimums have been obtained, and the four instruments are being daily observed under similar conditions. It

is believed that this alteration of zeros is mainly caused by the exposure of the bulbs to strong sunshine during summer.

During the year temperature ranged from 10°·8 on February 7 to 83°·7 on May 30. The mean temperature was 49°·1. The maximum reading in the sun's rays (black bulb *in vacuo*) was 141° on June 23, and the minimum temperature on the ground was −0°·2 on February 8. 1592 hours of bright sunshine were registered, giving a mean percentage of 33, which is 4 per cent above the average. September was a noticeable month, having a percentage of 56, being 20 per cent above the mean, and the maximum value for that month yet recorded here. The rainfall was 22·36 in., and the year was remarkable for the exceptionally dry months of February and June, the falls being 0·09 in. and 0·23 in. respectively. This is by far the lowest value for June during the past 36 years, the nearest approach being 0·68 in. in 1868. —*February* 25, 1896.

RADCLIFFE OBSERVATORY, OXFORD.—E. J. Stone, F.R.S., Radcliffe Observer.

The staff has remained unchanged during the year. The photographic and self-recording instruments have worked without failure, and are now in good order.

The eye-readings have been taken as usual, and reports sent daily by telegram to the Meteorological Office, monthly to the Registrar General and the local newspapers; and, upon application, to sanitary and other authorities. The weekly amounts of rainfall have, by particular request, been forwarded to the authorities at Windsor, who are interested in the prevention of floods in the valley of the Thames.

A set of photographic curves, showing the diurnal changes of temperature on fine days for the different months of the year, and others of general interest, were sent to the Exhibition of Photography held at the Imperial Institute during the summer.

A volume containing the results for 1888 and 1889 is now passing through the press, and will shortly be ready for distribution.

The following are the chief characteristics of the weather noted at Oxford in the year 1895 :—

The mean temperature of the air for the year was 48°·5, being 0°·3 below the mean for the last 67 years. The highest temperature in the shade was 83°·2 on September 27, and the lowest 7°·5 on February 8, the difference being 75°·7.

During the severe frost of February the temperature in the shade fell to 11°·1, 9°·3, 7°·5, and 9°·6 on February 6, 7, 8 and 9 respectively, whilst the grass minimum thermometer on the corresponding dates gave readings of 1°·0, 0°·3, −0°·1, and 0°·5; and the mean daily temperature of the air in shade for February was 28°·7, being 10°·8 below the mean for the last 67 years.

The month of September was remarkable for the high temperatures experienced, especially towards the end of the month, when maximum shade temperatures of 77°·5, 82°·3, 78°·4, 81°·6, 83°·2, 80°·6, 76°·1, and 75°·8 were recorded on the eight consecutive days, September 23 to 30; and the mean daily temperature in the shade for September was 60°·6, being 4°·8 above the mean for the last 67 years.

The total rainfall for the year was 23·867 in., being 2·429 in. below the mean for the last 80 years: the greatest monthly amounts were 3·597 in., 3·019 in., and 4·464 in. in July, October, and November.—*February* 7, 1896.

REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1895.

By EDWARD MAWLEY, F.R.H.S., President.

Plate II.

[Read February 19, 1896.]

The number of observers sending in returns in 1895 was 118, or 5 more than in the previous year. Since last year's report was issued the distribution of the observing stations has been still further improved, there being now 6 observers in Ireland South instead of 4, 10 in England East instead of 8, 4 in Scotland East instead of 1, and 3 in Scotland North instead of 1. For nearly all the new observers in these districts the Society is indebted to the kind assistance of Mr. Ernest Clarke, Secretary of the Royal Agricultural Society of England, Mr. James Macdonald, Secretary of the Highland and Agricultural Society of Scotland, and Mr. R. J. Moss, Registrar of the Royal Dublin Society.

The following changes have taken place in the observing stations since 1894:—No returns were received from Instow and Cardiff in District A; Greystones in District B; Bere Regis, Ashtead, Whatley, and Whitchurch in District C; Henley-in-Arden and Burbage in District D; Ellesmere and Egremont in District F; Ballymena in District G; Dalshangan in District H; and Low Fell in District I. On the other hand new stations have been started, or old ones revived, at the following places:—Liskeard in District A; Cork, Glendalough and Geashill in District B; Carisbrooke, Willinghurst and Farley in District C; Leominster and Ullenhall in District D; Wormley and Brundall in District E; Palé in District F; Clonbrock in District G; New Galloway in District H; Kirriemuir, Newmill, and Lhanbryde in District J; and Beauly and Dingwall in District K.

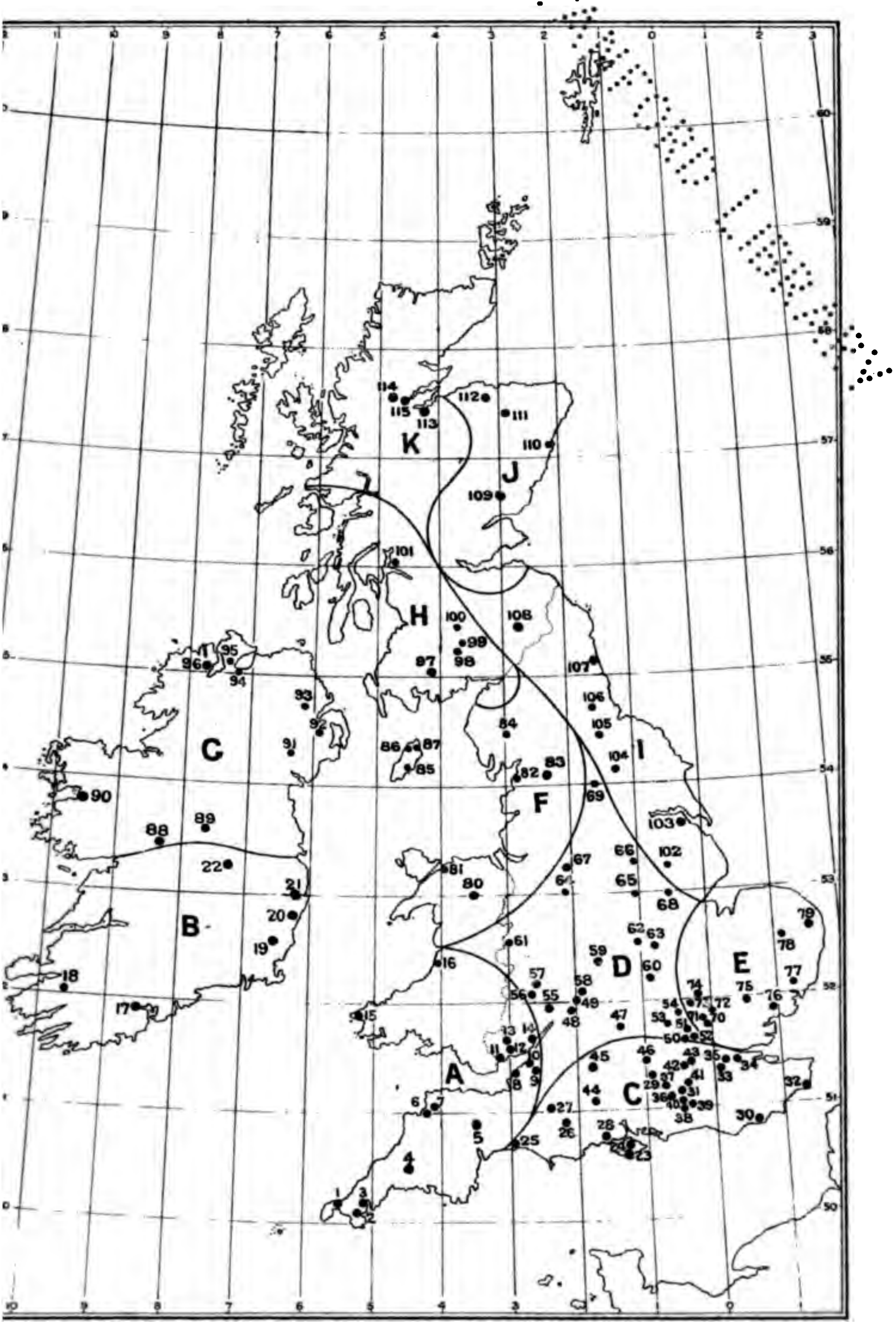
In former years it has been very difficult to check the observations sent in owing to the small number of previous records with which to compare them, but every year that passes makes this more practicable. As far as I have been able to examine the returns received for 1895, they appear to have been made, at most of the stations, with much care, and in accordance with the *Instructions* printed on the forms. In some cases, however, the observer has evidently not in the first instance selected the plants he has decided to observe with sufficient consideration. Consequently the dates for these badly selected plants come out year after year either abnormally early or late for the locality, the climate of which they are intended to represent.

The general accuracy of the observations will be shown by Table I.

The Winter of 1894-5.

December proved everywhere a warm winter month, but, on the other hand, January and February were both exceptionally cold—the departures in mean temperature from the average ranging from $-5^{\circ}\cdot4$ in the north of Ireland to $-6^{\circ}\cdot8$ in the west and east of Scotland, and in February from $-7^{\circ}\cdot3$ in the north of Scotland to $-11^{\circ}\cdot3$ in the mid-

MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1895.



For the Names of the Stations see List of Observers, Page 132.

Malby & Sons, Lith.

land counties of England. The total rainfall, including melted snow, for the winter quarter was more or less in defect of the mean in all districts, except the north-east of England. The December sunshine was variable, but in January and February nearly all the records were remarkably good for the time of year, particularly in the south-west and north-west of England, and in the west of Scotland.

TABLE I.—MEAN RESULTS, WITH THEIR VARIATIONS FROM THE ADOPTED AVERAGE, FOR THE 13 PLANTS IN ALL THE DISTRICTS WHERE THERE HAVE BEEN SUFFICIENT OBSERVERS TO WARRANT COMPARISONS BEING MADE.

YEARS.	Eng. S.W.		Eng. S.		Eng. Mid.		Eng. E.		Eng. N.W.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+13	144	+11	150	+14	147	+11	150	+13
1892	139	+ 8	138	+ 5	144	+ 8	143	+ 7	147	+10
1893	118	−13	122	−11	125	−11	123	−13	128	− 9
1894	126	− 5	130	− 3	135	− 1	127	− 9	137	0
1895	139	+ 8	138	+ 5	141	+ 5	138	+ 2	144	+ 7
Mean	133	+ 2	134	+ 1	139	+ 3	136	0	141	+ 4

Explanation of the Dates in the Tables.

1– 31	are in	January.	182–212	are in	July.
2– 59	,,	February.	213–243	,,	August.
60– 90	,,	March.	244–273	,,	September.
91–120	,,	April.	274–304	,,	October.
121–151	,,	May.	305–334	,,	November.
152–181	,,	June.	335–365	,,	December.

On the farms green keep of all kinds, favoured by the mild weather, continued unusually abundant until the close of 1894, while the young wheat at this time looked remarkably well, and was not too forward. Taking the whole of the United Kingdom a smaller area was planted with wheat than ever before known. The low prices at which this cereal had been selling in recent years must have been the principal cause, but it was no doubt to a certain extent due to the saturated condition of the soil in November preventing land intended for wheat from being then sown. Even before the new year had been entered upon a change to cold winter weather took place, and the frost that then set in lasted so long that everything remained at a complete standstill throughout the remainder of the season. Where the covering of snow was sufficiently deep the frost, although at times intense, did no harm, but where little had fallen, or where the land had been bared of snow by high winds, winter beans and all the turnips and swedes left in the ground perished, while cabbages, rape, and other forage crops suffered very severely. In exceptional cases even the wheat was killed.

In the gardens tender shrubs, such as the common laurel, Portugal laurel, laurestinus, and sweet bay, were everywhere more or less damaged by the frost and cutting North-easterly winds of February, and in some districts many shrubs were killed outright. The full extent of the injuries

inflicted was in certain cases not apparent until the sun had acquired sufficient power in the spring to start the plants into active growth, while in others evergreens, which at the end of the winter appeared greatly damaged, ultimately recovered with the loss only of their dead leaves. In the warmer parts of our islands, like the south-west of England, the

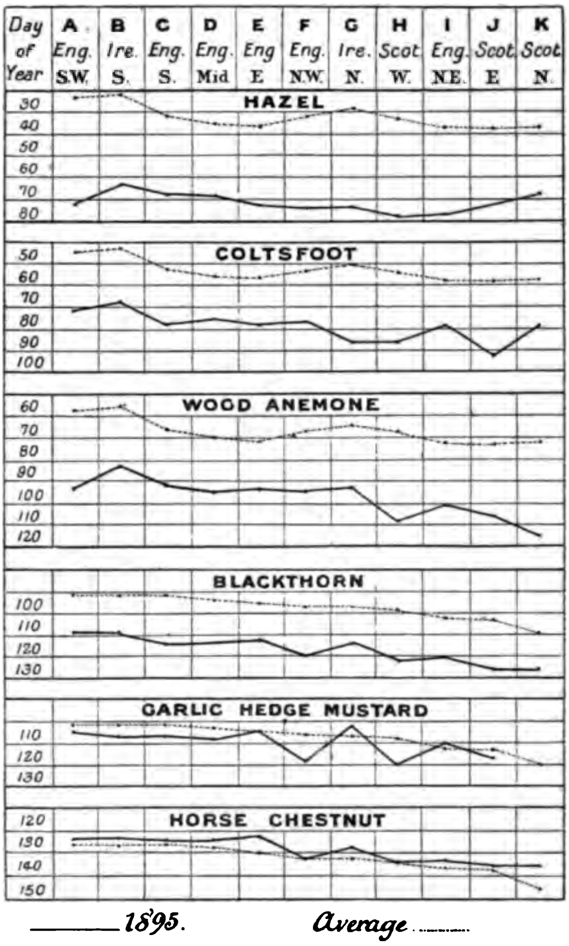


FIG. 1.—Mean dates (day of year) of flowering of plants in 1895, and also the average dates.

damage done to delicate trees and shrubs was, perhaps, most keenly felt, owing to the unusual size many of the individual specimens had there attained. It is a somewhat remarkable fact that certain kinds of shrubs, herbaceous plants and bulbs, which had passed almost uninjured through the severe winter of 1892-3, fell easy victims to the frosts of last winter, whereas other kinds suffered very much more during the former of these winters. Nowhere was the effect of the frost so evident at a glance as

on the commons, where throughout the length and breadth of the land all the gorse, with the exception of a green shoot here and there, had been to all appearance killed. In most localities, however, a good many of the stems were afterwards discovered still alive, although all the spines on them had been destroyed.

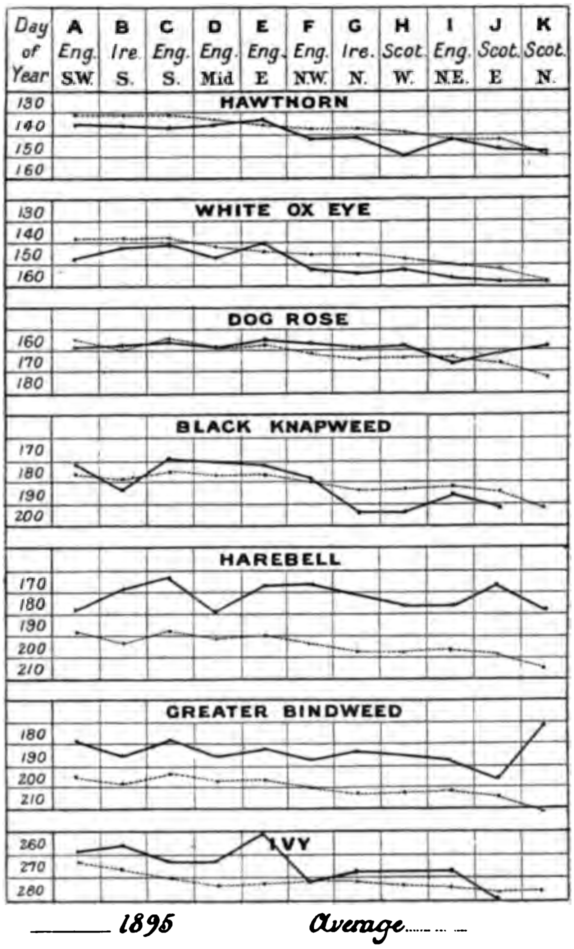


FIG. 2.—Mean dates (day of year) of flowering of plants in 1895, and also the average dates.

Large numbers of our native birds perished of starvation through their usual supplies of food having been entirely cut off for weeks together. Those most frequently mentioned by the observers as having been found dead were starlings, thrushes, blackbirds, rooks, and larks. During February gulls and other sea-birds are reported as having in some places become so tame that they flocked to the houses in the towns in order to be fed. Rabbits and hares were also great sufferers, and in some localities

numbers were killed. In the Highlands of Scotland the deer were driven from their usual haunts in search of food, and were often to be met with in a half-starved condition. As is frequently the case in exceptionally cold winters, birds seldom to be seen at other times visited our shores. Among the most noteworthy of these northern visitors was the little auk, thousands of which arrived on the north and north-east coasts of Scotland and England in an exhausted condition during February.

Much damage was done to trees, particularly in Scotland and the north of England, by the severe gale of December 21st and 22nd, an excellent account of which was given by Mr. Harding, F.R.Met.Soc., in a paper read before the Society last year at the January meeting.

The song-thrush did not begin singing until much after its usual time. Indeed, the mean date for the British Isles is three weeks later than the average for the previous four years.

The Spring.

The weather became gradually more and more unseasonably warm and dry as the spring advanced, but it was only in May that the variations from the mean as regards temperature or rainfall were in any way exceptional. In March and April the duration of bright sunshine fell short of the average in most districts, the only noteworthy exceptions being England North-east and Scotland East, where April proved an unusually bright month. May, on the contrary, was everywhere, if we except Ireland South and Scotland North, remarkably sunny.

In the very interesting paper on the "Frost of January and February 1895 over the British Isles," by Mr. F. C. Bayard and Mr. W. Marriott, we are told that this frost lasted over nine weeks, and came to an end on March 5th. The ground had, however, by that time become frozen to such a very unusual depth, and the thaw was at first so gradual that it was not until about the second or third week in March that vegetation began to show any decided signs of revival. All soils, and especially those of a retentive nature, had benefited greatly by the disintegrating effect of the frost, so that the land required but little preparation by the farmer for the reception of spring corn and other early crops. The fall of rain during the spring quarter proved very light, but it was only after the middle of May that the drought began to be seriously felt. Indeed, in the early part of that month the prospect for nearly all kinds of farm produce was, on the whole, very promising. The pastures were the first to receive a check from the continued dryness of the soil, but its stunting influence, aided by the cold North-easterly winds, which for a time prevailed, soon extended to the corn and other crops.

Scarcely any green vegetables were to be found in the kitchen gardens, the winter frosts having destroyed not only cabbages but also most of the Brussels sprouts.

The fierce gale of March 24th proved very destructive to trees, particularly in the eastern and midland counties of England. Mr. A. W. Preston, F.R.Met.Soc., in a paper read before the Norfolk and Norwich Naturalists' Society, estimated that in Norfolk alone something like 100,000 trees had been blown down, while Mr. J. Hopkinson, F.R.Met.Soc., describes it as having been one of the most destructive gales ever experienced in Hertfordshire.

The hawthorn flowered very sparsely in most places, in fact, many bushes had no blossom on them at all.

The only insect pests which appeared to have been in any way seriously affected by the cold winter were aphides, the almost entire absence of which was one of the most remarkable features of the season. On the other hand, slugs and snails, until the dry weather gradually put a stop to their movements, were especially numerous and destructive.

Owing to the prolonged frost of the winter, and the continued coldness of the ground for some time afterwards, the first flowers on the hazel made their appearance at an exceptionally late date, in fact, a month later than in any of the four previous years. The coltsfoot, wood anemone, and blackthorn, were also in most districts more backward in flowering than in any of those years; whereas the garlic hedge mustard, the hawthorn, and the white ox eye were only moderately late in coming into blossom, and appeared earlier than in either 1891 or 1892. The horse-chestnut flowered in nearly all parts of the country at a slightly earlier date than the mean.

According to the returns sent in all the spring migrants on the list, the swallow, the cuckoo, the nightingale, and the fly-catcher appeared in this country a few days earlier than their mean dates of arrival for the preceding four years.

The honey-bee, the wasp, the small white butterfly, and the orange tip butterfly, made their appearance later than their average dates for the four previous years.

The Summer.

June and August were moderately warm months, while July, on the other hand, proved moderately cold, but taking the summer season as a whole, the mean temperature was only slightly above the average. In June the rainfall was very light, but during July and August, taken together, much more than a seasonable quantity of rain fell. If we except the south of Ireland, the record of sunshine for the quarter comes out considerably in excess of the mean in most of the other districts.

Owing to the persistent drought, the hay crop proved everywhere an exceedingly light one, but was harvested in capital condition. The corn made but little growth, and was unusually short and slender in the straw. Turnip and mangold seed failed in many cases to germinate, and had to be resown. Moreover, the supply of grass for the cattle and sheep became extremely short, and in many places the sheep had to be turned into the cornfields. This drought, taking the British Isles as a whole, was more generally felt than that of 1893. It was not nearly as severe in most parts of England, but considerably more so both in Scotland and Ireland.

Towards the end of the dry period the harvest promised to be one of the earliest and shortest on record, but no sooner was the corn ready to cut in the earlier districts than wet and stormy weather set in, and the cutting and ingathering were from that time greatly hindered by rain. In fact it was not until after the middle of August that any great progress was made. Although the change to wet weather rendered the harvest a long and tedious one, it proved a great boon to the pasture lands, and also to the roots. The grass, which had previously been quite brown, grew rapidly when the warm soil had become sufficiently moistened by

rain. The weeds, which had given little trouble in the early part of the summer, also made rapid growth, and were with difficulty kept under.

In the middle of June there occurred in most districts a frost which did little damage generally, but in low-lying lands, particularly where exposed to the morning sun, potatoes, dahlias, and other tender plants were cut to the ground. Flower and other seeds sown in May, in many cases, owing to the drought, did not come up until after the July rains. There were comparatively few butterflies, and as was the case in the spring scarcely any aphides were anywhere to be seen.

Taking the British Isles as a whole, the dog rose flowered somewhat in advance of its average date, whereas the black knapweed was, if anything, rather late. The harebell came into blossom three weeks early, and the greater bindweed more than a fortnight early, as compared with their respective means.

The meadow brown butterfly made its appearance about the same time as in 1894, but considerably later than in either of the two previous years.

The Autumn.

During a great part of September the weather was extremely warm throughout the whole country, the departures in mean temperature from the average varying from $+ 2^\circ{\cdot}8$ in the south of Ireland to $+ 4^\circ{\cdot}8$ in the midland counties of England; whereas October and November were everywhere of about average warmth. During September scarcely any rain fell, but the two following months were wet in nearly all districts. The record of sunshine in September was remarkably good, except in the north of Scotland, where, on the other hand, it was much below the average. In October and November also the total duration in most districts exceeded the mean. Taken as a whole this was a singularly sunny autumn.

Nearly all the corn had been got in by the end of the second week in September, and during the latter part of the harvest the weather continued very favourable. The second crop of hay, which proved an unusually heavy one, was also gathered in brilliant weather. The want of rain in September, together with the great heat, soon, however, caused the pastures to become once more quite brown, while the root crops showed signs of flagging. This second drought fortunately lasted only about a month, when a return to cool and wet weather took place. By the middle of October enough rain had fallen on the warm ground to make the grass-lands look green again, and to swell the root crops. From this time until the close of the year there was never any lack of keep in the pastures. Wheat-sowing was carried on rapidly during the latter half of October, but little was possible in November owing to the persistent rains, until towards the close of the month. At the end of the season the soil was left in an unusually fertile condition owing to the beneficial influence of the brilliant sunshine of the spring, summer, and autumn, while the new growths on fruit and other trees and shrubs had, through the remarkably sunny weather of the autumn, become singularly well matured.

As might have been expected after such a long period of warm and dry weather in the spring and early summer, followed by a wet August,

and an unusually warm September, the instances of second flowering and fruiting were especially numerous during October and November. Wild roses, dogwood, and other wild shrubs flowered freely a second time, and in the gardens ripe strawberries and raspberries were quite common. Most deciduous trees, favoured by the warmth and moisture of the ground and the absence of sharp frosts, retained their green leaves until an unusually late period in the year. The autumn tints were, as a rule, poor, and the foliage of trees, when once it began to fall, soon disappeared. The hips on the wild roses were abundant, but there were scarcely any berries at all on either the hawthorn or holly.

The yield of all the farm crops, with the exception of potatoes, was very poor. According to the official Report, the estimated average yield of wheat per acre, in Great Britain, was smaller than in any of the previous ten years, except 1893. In the case of barley the only exceptions were 1887 and 1893, while oats yielded smaller crops in but three of the ten years, viz. 1885, 1887, and 1893. The corn harvest began about a week earlier than the average date for the previous five years, and earlier than in any of those years, with the exception of 1893.

There was a heavy crop of apples, but most of the earlier sorts kept badly when gathered, owing to the warm autumn rains causing the fruit to swell after it had become partially matured. Pears and plums, on the other hand, yielded indifferently, but strawberries and all the bush fruits were unusually abundant.

The wild ivy flowered in nearly all the districts in advance of its mean date, and earlier than in any of the preceding four years, except 1893.

The last swallows as a rule took their departure earlier than in any of the four previous autumns, except that of 1893.

The Year.

The weather of the phenological year of 1895 in many respects resembled that of 1893, for it began with a very cold winter, which was followed by a dry spring and early summer. In both years there occurred a second drought, while the record of bright sunshine was in each case remarkably good. All the first spring flowers made their appearance singularly late, but the departures from the average dates of first flowering gradually decreased as the season advanced. It was not, however, until the middle of June that plants began to come into blossom in advance of their usual time. During July the dates recorded were, as a rule, exceptionally early.

The yield of all the farm crops, except potatoes, was exceedingly poor. As in 1893, the one redeeming feature of the year, from an agricultural point of view, was the autumn, the glorious weather of which greatly favoured the completion of the harvest, the growth of the grass and roots, and the cultivation of the land. Pears and plums yielded badly, but there was a splendid crop of apples, and also of all the small fruits.

As regards vegetation generally, seldom has a year ended under conditions so favourable for the one succeeding it.

TABLE II.—LIST OF OBSERVERS.

Station.	County.	Height above Sea-level.	Observer.
A		Ft.	
1. Marazion	Cornwall	40	F. W. Millett.
2. Mawnan Smith	Cornwall	200	Miss R. Barclay.
3. Falmouth	Cornwall	190	Miss Willmore.
4. Liskeard	Cornwall	400	S. W. Jenkin, C.E.
5. Tiverton	Devon	270	Miss M. E. Gill.
6. Westward Ho	Devon	130	Miss Patterson.
7. Barnstaple	Devon	90	T. Wainwright.
8. Sidcot	Somerset	200	W. F. Miller.
9. Long Ashton	Somerset	280	Miss H. Dawe.
10. Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
11. Penarth	Glamorgan	120	G. A. Birkenhead.
12. Castleton	Glamorgan	80	F. G. Evans, F.R.Met.Soc.
13. Bassaleg	Monmouth	25	W. J. Grant.
14. St. Arvan's	Monmouth	360	Miss M. Peake.
15. St. David's	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
16. Aberystwith	Cardigan	30	J. H. Salter, B.Sc.
B			
17. Cork	Cork	100	R. A. Phillips.
18. Killarney	Kerry	100	Ven. Archdeacon Wynne, D.D.
19. Ferns	Wexford	260	G. E. J. Greene, F.L.S.
20. Woodenbridge	Wicklow	300	J. Hunter.
21. Glendalough	Wicklow	460	Mrs. W. Wynne.
22. Geashill	King's County	280	Rev. Canon Russell.
C			
23. Carisbrooke	Isle of Wight	...	R. M. Prideaux.
24. Bembridge	Isle of Wight	80	C. Orchard.
25. Whitchurch Canonicorum	Dorset	150	Miss Mules.
26. Blandford	Dorset	270	J. C. Mansell-Pleydell, F.G.S., F.L.S.
27. Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth.
28. Pennington	Hants	100	Miss E. S. Lomer.
29. Strathfield Turgiss	Hants	200	Rev. C. H. Griffith.
30. Bexhill-on-Sea	Sussex	10	H. Le M. Dunn.
31. Muntham	Sussex	250	P. S. Godman, F.Z.S.
32. Dover	Kent	150	F. D. Campbell.
33. Farnborough	Kent	350	F. G. M. Kelly.
34. Swanley	Kent	160	C. H. Hooper.
35. Chislehurst	Kent	360	Miss F. Duncan.
36. Coneyhurst	Surrey	600	J. Russell.
37. Churt Vicarage	Surrey	350	Rev. A. W. Watson.
37. Churt	Surrey	300	C. Criddle.
38. Cranleigh	Surrey	180	Admiral J. P. Maclear, F.R.Met.Soc.
39. Winterfold	Surrey	580	R. Turvey.
40. Willinghurst	Surrey	400	A. Nash.
41. Oxshott	Surrey	210	W. H. Dines, B.A., F.R.Met.Soc.
42. Addlestone	Surrey	100	C. U. Tripp, M.A., F.R.Met.Soc.
43. East Molesey	Surrey	40	Lady Jenkyns.
44. Farley	Wilts	350	Miss F. C. Henderson. Miss D. Parsons.
45. Marlborough	Wilts	480	E. Meyrick.
46. Reading	Berks	...	H. Goadby.
D			
47. Oxford	Oxford	200	F. A. Bellamy, F.R.Met.Soc.
48. Cheltenham	Gloucester	250	M. L. Evans.

TABLE II.—LIST OF OBSERVERS—*Continued.*

STATION.	COUNTY.	Height above Sea-level.	OBSERVER.
		Ft.	
49. Beckford	Gloucester	120	F. Slade, F.R.Met.Soc.
50. Watford	Herts	240	Mrs. G. E. Bishop.
51. St. Albans (The Grange)	Herts	380	Mrs. Hopkinson.
51. St. Albans (Addiscombe Lodge)	Herts	400	Miss E. F. Smith.
51. St. Albans (Warley Road)	Herts	300	H. Lewis.
52. Radlett	Herts	320	Miss E. M. Lubbock.
53. Berkhamsted	Herts	400	Mrs. E. Mawley.
54. Harpenden	Herts	370	J. J. Willis.
55. Ross	Hereford	210	H. Southall, F.R.Met.Soc.
56. Breinton	Hereford	230	H. A. Wadworth, F.R.G.S.
57. Leominster	Hereford	220	J. H. Arkwright.
58. Evesham	Worcester	120	Rev. D. Davis, B.A.
59. Ullenhall	Warwick	400	Mrs. Coldicott.
60. Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
61. Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
62. Thurcaston	Leicester	250	Rev. T. A. Preston, M.A., F.R.Met.Soc.
63. Uppingham	Rutland	300	G. W. S. Howson, M.A.
64. Tean	Stafford	470	Rev. G. T. Ryves, F.R.Met.Soc. Miss M. G. B. Ryves.
65. Beeston	Notts	210	G. Fellows.
66. Hodsock	Notts	60	Miss Mellish, F.R.H.S.
67. Macclesfield	Cheshire	500	J. Dale.
68. Belton	Lincoln	200	Miss F. H. Woolward.
69. Harrogate	Yorkshire	340	J. Farrah, F.R.Met.Soc.
E			
70. Wormley	Herts	120	Miss Lilian Warner.
71. Hatfield	Herts	300	T. Brown.
72. Hertford	Herts	140	W. Graveson.
73. Hitchin	Herts	230	J. E. Little, M.A.
74. Ashwell	Cambridge	260	H. G. Fordham.
75. Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
76. Lexden	Essex	90	Miss Carver.
77. Sproughton	Suffolk	30	Rev. A. Foster-Melliar.
78. Tacolneston	Norfolk	190	Miss E. J. Barrow.
79. Brundall	Norfolk	70	A. W. Preston, F.R.Met.Soc.
F			
80. Palé	Merioneth	600	T. Ruddy.
81. Penmaenmawr	Carnarvon	350	A. T. Johnson.
82. Claughton	Lancashire	80	Mrs. K. Green.
83. Giggleswick	Yorkshire	500	E. Peake, M.A.
84. Ambleside	Westmoreland	260	Miss M. L. Hodgson.
85. Cronkbourne	Isle of Man	110	A. W. Moore. J. Murphy.
86. Orry's Dale	Isle of Man	70	Miss C. G. Crellin.
87. Sulby	Isle of Man	80	H. S. Clarke, F.E.S.
G			
88. Clonbrock	Galway	200	Hon. R. E. Dillon.
89. Edgeworthstown	Longford	270	J. M. Wilson, B.A.
90. Westport	Mayo	10	J. M. McBride.
91. Loughbrickland	Down	350	Rev. H. W. Lett, M.A.
92. Saintfield	Down	310	Rev. C. H. Waddell, M.A.
93. Antrim	Antrim	70	Rev. W. S. Smith.

TABLE II.—List of Observers—*Continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
94. Londonderry	Londonderry	450	T. Gibson.
95. Ballynagard	Londonderry	30	Miss A. M. Campbell.
96. Ramelton	Donegal	200	Miss K. Swiney.
H			
97. New Galloway	Kirkcudbright	450	T. R. Bruce.
98. Tynron	Dumfries	520	J. Shaw.
99. Thornhill	Dumfries	300	J. Fingland.
100. Jardington	Dumfries	100	J. Rutherford.
101. Helensburgh	Dumbarton	100	Miss Muirhead.
I			
102. Doddington	Lincoln	90	Rev. R. E. Cole.
103. Great Cotes	Lincoln	...	J. Cordeaux.
104. Thirsk	Yorks (N. R.)	120	A. B. Hall.
105. East Layton	Yorks (N. R.)	570	Mrs. E. O. Maynard Proud.
106. Durham	Durham	350	H. J. Carpenter.
107. Cambois	Northumberland	20	S. Dunnett.
108. Lilliesleaf	Roxburgh	530	Miss O. R. Carre.
J			
109. Kirriemuir	Forfar	250	T. M. Nicoll.
110. Aberdeen	Aberdeen	40	P. Harper.
111. Newmill	Banff	350	J. Ingram.
112. Lhanbryde	Elgin	50	J. Cruikshank. W. Taylor.
K			
113. Beauly	Inverness	60	A. Birnie.
114. Inverbroom	Ross	50	J. A. Fowler.
115. Dingwall	Ross	10	J. P. Smith, M.D.

The numbers before the names of the stations refer to their position on the map of the stations (Plate II).

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1895.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse-chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
A													
Marazion	64	61	...	109	...	...	136	*170*	153	*200*	...	187	263
Mawnan Smith	75	...	96	106	115	125	138	...	...	185	...	192	258
Falmouth	83	48	108	107	114	119	135	141	160	174	...	173	240
Liskeard	71	72	102	105	...	127	141	...	...	...	...	...	...
Tiverton	...	...	91	110	...	120	135	147	156	166	...	...	268
Westward Ho	...	...	...	121	121	130	141	161	167	177	...	187	...
Barnstaple	76	81	93	108	109	121	137	151	159	178	...	173	269
Sidcot	67	82	82	104	121	128	143	150	157	164	...	162	271
Long Ashton	66	72	94	116	112	123	135	142	166	...	190	...	*308*
Clifton	...	...	...	114	...	124	132	...	...	...	...	...	...

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1895—*Continued.*

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse-chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
Castleton	71	66	82	109	112	120	130	140	151	165	193	181	263
Bassaleg	71	75	98	113	...	120	135	139	160	166	...	176	255
St. Arvan's	71	69	81	115	115	126	141	151	154	166	...	189	247
St. David's	...	75	...	92	...	...	123	154	...	174	...	175	...
Aberystwith	74	75	100	107	109	128	130	140	...	...	151	...	...
B													
Cork	...	...	...	114	...	120	129	137	157	184	...	174	242
Killarney	48	62	78	100	116	108	128	144	153	179	169	178	245
Ferns	65	71	79	111	122	126	135	139	159	190	...	198	265
Woodenbridge	74	...	...	...	...	129	136	143	159	...	...	185	268
Glendalough	65	71	93	111	...	127	144	142	161	179	...	190	266
Geashill	...	...	...	...	113	127	144	149	160	...	...	...	...
C													
Carisbrooke	79	74	95	115	116	126	143	...	...	163	...	...	...
Bembridge	59	58	...	112	115	124	134	133	160	175	167	...	...
Whitchurch Canonicorum	*11*	72	80	107	114	...	137	141	...	...	...	...	...
Blandford	57	78	94	116	121	127	143	141	157	169	169	198	269
Buckhorn Weston	72	74	96	117	107	127	135	136	155	159	...	167	258
Pennington	66	...	...	116	115	122	...	...	161	156	159	...	262
Strathfield Turgiss	69	90	99	110	118	127	132	137	155	157	159	161	266
Bexhill-on-Sea	80	94	87	117	109	126	145	145	150	...	...	...	288
Muntham	59	75	81	108	108	*109*	138	138	156	172	...	178	275
Dover	...	...	...	121	...	127	150	...	...	...	...	...	263
Farnborough	73	71	84	116	112	...	134	140	...	...	...	...	...
Swanley	73	71	91	117	121	126	133	150	156	198	...	194	...
Chislehurst	34	72	82	112	120	121	136	142	157	190	172	185	262
Coneyhurst	72	89	87	118	123	134	137	136	151	...	157	167	253
Churt Vicarage	72	94	95	119	118	128	135	145	159	161	161	175	...
Churt	58	95	97	118	115	126	130	140	*146*	161	155	196	237
Cranleigh	73	85	88	110	118	122	137	141	156	160	...	174	268
Winterfold	64	68	88	115	...	131	148	149	...	...	...	...	...
Willinghurst	...	82	89	115	...	...	136	...	...	...	...	...	...
Oxshott	75	79	100	112	122	121	132	144	158	...	...	185	...
Addlestone	62	79	98	112	119	128	135	144	158	160	169	172	...
East Molesey	77	...	...	112	114	120	130	140	161	168	*191*	183	274
Farley	*26*	...	86	110	114	122	...	141	153	...	166	168	...
Marlborough	70	70	84	116	121	128	139	146	154	164	164	179	240
Reading	74	76	104	111	...	119	132	...	...	...	...	...	...
D													
Oxford	...	76	...	100	111	123	...	...	...	...	...	181	255
Cheltenham	79	81	91	111	119	123	134	147	151	167	187	195	253
Beckford	57	60	90	112	116	125	130	134	149	159	167	174	252
Watford	58	...	106	93	105	*101*	122	*119*	*129*	...	189	187	276
St. Albans (The Grange)	64	...	97	109	116	122	132	143	153	155	203	194	257
St. Albans (Addiscombe Lodge)	74	*98*	104	107	117	123	...	138	160	165	169	...	...
Radlett	76	81	89	118	120	124	133	148	161	186	...	186	...
Berkhamsted	71	72	100	118	117	126	142	148	150	171	169	167	261
Harpenden	73	84	90	115	110	127	140	146	154	169	204	...	...

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1895—*Continued.*

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse-chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
Ross	76	72	...	113	...	...	131	...	...	...	...	...	...
Breinton	74	77	81	115	115	124	131	144	...	...	...	...	...
Leominster	...	...	...	...	...	...	...	...	...	...	...	200	...
Evesham	54	67	104	111	117	124	131	136	155	183	...	...	...
Ullenhall	72	56	92	114	115	113	140	132	161	...	189	201	282
Northampton	72	75	81	113	120	127	135	143	152	170	175	178	244
Churchstoke	76	77	98	120	127	128	140	139	167	...	...	182	260
Thurcaston	76	*97*	99	117	118	128	132	152	155	152	170	196	270
Uppingham	75	...	...	...	...	131	...	...	155	...	...	...	...
Tean	...	...	96	...	...	...	...	...	160	...	160	...	...
Beeston	71	79	...	113	136	129	137	153	164	166	154	...	...
Hodsock	59	70	82	110	118	118	134	151	154	174	175	168	250
Macclesfield	77	100	116	124	138	133	144	161	167	189	189	191	273
Belton	74	71	89	112	121	125	131	147	159	...	...	...	...
Harrogate	34	76	92	120	120	133	147	144	167	170	185	179	280
E													
Wormley	74	76	90	113	121	122	131	139	...	166	186	181	...
Hatfield	73	89	102	111	...	121	130	144	...	...	...	...	...
Hertford	62	69	83	102	108	123	129	136	160	165	174	185	251
Hitchin	73	76	94	113	110	118	131	136	146	157	153	180	252
Ashwell	69	76	...	112	...	...	...	...	149	...	...	...	253
Bocking	78	81	102	115	111	124	140	151	159	166	...	...	242
Lexden	*4*	...	93	107	119	118	133	...	...	...	170	...	257
Sproughton	70	77	88	114	121	125	134	141	156	...	...	...	258
Tacolneston	74	76	92	117	115	...	...	...	...	...	...	...	...
Brundall	76	84	100	118	111	124	137	136	161	198	...	181	264
F													
Palé	...	...	...	...	131	131	149	156	161	192	163	191	287
Penmaenmawr	76	80	...	112	...	...	134	146	160	...	...	*213*	...
Claughton	...	84	99	127	129	...	146	154	159	180	181	197	...
Giggleswick	76	76	...	...	...	133	150	153	159	171	166	187	...
Ambleside	69	79	91	120	126	130	137	149	152	170	162	183	255
Cronkbourne	...	...	*118*	...	...	144	147	145	...	...	*133*	...	272
Orry's Dale	*102*	61	...	*132*	...	123	134	151	152	...	154	177	...
G													
Clonbrock	...	...	92	114	...	...	...	...	...	...	...	...	...
Edgeworthstown	...	...	*123*	116	...	...	132	...	157	...	...	...	...
Westport	75	...	82	111	...	117	136	...	...	...	...	...	*201*
Loughbrickland	85	88	103	115	...	134	146	156	161	...	...	...	...
Saintfield	71	70	90	117	...	132	148	157	166	...	...	...	267
Antrim	...	93	...	115	112	129	146	148	158	190	...	*212*	269
Londonderry	71	89	103	124	...	132	...	...	...	199	...	...	...
Ballynagard	65	...	...	109	...	...	138	...	157	...	...	184	...
Ramelton	...	...	...	114	...	126	...	151	153	194	...	...	...
H													
New Galloway	77	...	111	125	...	140	...	*179*	156	...	...	...	...
Tynron	79	103	107	124	...	134	156	155	157	202	169	...	...
Thornhill	83	91	109	121	*147*	...	...	155	159	...	...	...	...
Jardington	78	79	100	124	...	130	147	152	157	186	151	...	...
Helensburgh	75	66	120	115	130	133	148	147	159	*211*	209	...	...

TABLE III.—DATE (DAY OF YEAR) OF FIRST FLOWERING OF PLANTS, 1895—*Continued.*

STATION.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic Hedge Mustard.	Horse-chestnut.	Hawthorn.	White Ox Eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bind-weed.	Ivy.
I													
Doddington	77	75	89	115	120	125	135	148	159	180	161	173	...
Thirsk	62	74	90	111	113	129	132	147	163	177	163	182	267
East Layton	79	89	105	123	128	129	146	170	172	...	...	...	269
Durham	77	85	93	125	...	140	147	160	171	...	173	...	...
Cambois	...	73	105	119	*151*	147	150	157	166	199	198	205	...
Lilliesleaf	90	*122*	117	128	...	135	143	154	159	...	185	193	*316*
J													
Kirriemuir	...	...	...	...	...	...	...	154	156	186	157	...	...
Aberdeen	...	84	110	...	...	145	149	169	173	193	198	...	...
Newmill	*118*	96	104	126	127	138	150	153	160	193	167	196	280
Lhanbryde	...	100	105	...	...	129	142	155	155	...	144	...	...
K													
Beauly	...	...	...	131	...	130	149	155	158	...	182	...	...
Inverbroom	68	79	115	122	...	141	148	160	157	...	180	...	...
Dingwall	...	...	...	...	...	...	...	...	161	...	175	171	...

The dates in *italics* have not been taken into consideration when calculating the means given in Table IV.

OBSERVERS' NOTES.

DECEMBER 1894.—*Mawnan Smith* (A)—24th. Trees still green. Laurustinus in full flower for Christmas decorations. 30th. First snow, laurustinus much cut and spoilt. *Falmouth* (A)—24th. A camellia fully out in the open air. *Tiverton* (A)—31st. Dug new potatoes in the garden from small ones left in the ground. *Killarney* (B)—21st. Mignonette, pansy, doronicum, chrysanthemum, polyanthus, China and other roses, anemone, yellow marguerite, wallflower, violet, cytisus, and aubretia in flower. *Bembridge* (C)—25th. A good many flowers still to be had in the gardens, including numerous primroses and polyanthuses. *Buckhorn Weston* (C)—18th. Picked a lesser celandine and ripe wild strawberry. *Pennington* (C)—28th. Spurge laurel in flower. *Churt Vicarage* (C)—24th. Sixteen different kinds of flowers still in bloom in my garden, including laurustinus, strawberry, cowslip, and rose. *St. Albans* (*The Grange*) (D)—White ox eye in flower during the greater part of month. Rooks building at The Grange, Welwyn, for several days before Christmas. *Berkhamsted* (D)—1st. Dahlias killed. 31st. Last rose bloom of the year destroyed by frost. *Brundall* (E)—22nd. Violent South to West gale. *Penmaenmawr* (F)—Unusually large flocks of redwings, fieldfares, and starlings. *Ambleside* (F)—22nd. Fierce storm, wrecking many trees. *Ballynagard* (G)—21st. Terrific gale, which uprooted a great number of trees and blighted almost all the shrubs which were in the least exposed. *Tynron* (H)—22nd. Tremendous wind at 9.30 a.m., my large cherry-tree blown down. Fearful destruction worked among the woods, worse than in winter of 1893-4. *Cambois* (I)—25th. Wallflowers, pansies, and carnations still in flower in cottage gardens.

TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF PLANTS IN 1895, AND THEIR VARIATIONS FROM THE AVERAGE.

PLANTS.	A. England, S.W.			B. Ireland, S.			C. England, S.			D. England, Mid.		
	1895.	Approximate Average.	Variation from Average.	1895.	Approximate Average.	Variation from Average.	1895.	Approximate Average.	Variation from Average.	1895.	Approximate Average.	Variation from Average.
Hazel	72	23	+49	63	21	+42	68	31	+37	69	35	+34
Coltsfoot	71	44	+27	68	42	+26	78	52	+26	75	56	+19
Wood Anemone	93	58	+35	83	56	+27	91	66	+25	95	70	+25
Blackthorn	109	91	+18	109	91	+18	114	91	+23	113	93	+20
Garlic Hedge Mustard	114	111	+ 3	117	111	+ 6	116	111	+ 5	119	113	+ 6
Horse-chestnut	124	126	− 2	123	126	− 3	125	126	− 1	125	128	− 3
Hawthorn	135	131	+ 4	136	131	+ 5	137	131	+ 6	135	133	+ 2
White Ox Eye	147	139	+ 8	142	139	+ 3	141	139	+ 2	145	141	+ 4
Dog Rose	158	156	+ 2	158	160	− 2	156	155	+ 1	158	158	Av.
Black Knapweed	171	175	− 4	183	179	+ 4	168	174	− 6	170	177	− 7
Harebell	178	189	−11	169	193	−24	163	188	−25	179	191	−12
Greater Bindweed	179	195	−16	185	199	−14	179	194	−15	185	197	−12
Ivy	259	263	− 4	257	266	− 9	263	270	− 7	263	274	−11
Mean for the 13 Plants	139	131	+ 8	138	132	+ 6	138	133	+ 5	141	136	+ 5

PLANTS.	E. England, E.			F. England, N.W.			G. Ireland, N.			H. Scotland, W.		
Hazel	72	36	+36	74	32	+42	73	29	+44	78	33	+45
Coltsfoot	78	57	+21	76	53	+23	85	50	+35	85	54	+31
Wood Anemone	94	71	+23	95	67	+28	94	64	+30	109	68	+41
Blackthorn	112	95	+17	120	97	+23	115	97	+18	122	99	+23
Garlic Hedge Mustard	115	115	Av.	128	117	+11	112	117	− 5	130	119	+11
Horse-chestnut	122	130	− 8	132	132	Av.	128	132	− 4	134	134	Av.
Hawthorn	133	135	− 2	142	137	+ 5	141	137	+ 4	150	139	+11
White Ox Eye	140	143	− 3	151	145	+ 6	153	145	+ 8	152	147	+ 5
Dog Rose	155	157	− 2	157	161	− 4	159	164	− 5	158	164	− 6
Black Knapweed	172	176	− 4	178	180	− 2	194	183	+11	194	183	+11
Harebell	166	190	−24	165	194	−29	...	197	...	176	197	−21
Greater Bindweed	182	196	−14	187	200	−13	184	203	−19	...	203	...
Ivy	254	273	−19	271	271	Av.	268	271	− 3	...	273	...
Mean for the 13 Plants	138	136	+ 2	144	137	+ 7	142*	133*	+9*	135†	122†	+13†

PLANTS.	I. England, N.E.			J. Scotland, E.			K. Scotland, N.			British Isles.		
Hazel	77	37	+40	...	38	...	68	37	+31	71	31	+40
Coltsfoot	79	58	+21	93	59	+34	79	58	+21	79	53	+26
Wood Anemone	100	72	+28	106	73	+33	115	72	+43	98	67	+31
Blackthorn	120	102	+18	126	103	+23	127	110	+17	117	97	+20
Garlic Hedge Mustard	120	122	− 2	127	123	+ 4	...	130	...	120	116	+ 4
Horse-chestnut	134	137	− 3	137	138	− 1	136	145	− 9	129	132	− 3
Hawthorn	142	142	Av.	147	143	+ 4	149	150	− 1	141	137	+ 4
White Ox Eye	156	150	+ 6	158	151	+ 7	158	158	Av.	149	145	+ 4
Dog Rose	165	163	+ 2	161	166	− 5	159	173	−14	159	162	− 3
Black Knapweed	185	182	+ 3	191	185	+ 6	...	192	...	181	179	+ 2
Harebell	176	196	−20	167	199	−32	179	206	−27	172	194	−22
Greater Bindweed	188	202	−14	196	205	− 9	171	212	−41	184	200	−16
Ivy	268	274	− 6	280	277	+ 3	...	276	...	265	271	− 6
Mean for the 13 Plants	147	141	+ 6	157*	152*	+5*	134‡	132‡	+2‡	143	137	+ 6

* For 12 Plants. † For 11 Plants. ‡ For 10 Plants.

\+ indicates the number of days later than the average date.
− ,, ,, ,, earlier ,, ,,
Av. ,, average date.

JANUARY 1895.—*Mawnan Smith* (A)—7th. Nasturtiums killed. *St. Arvan's* (A)—29th. Birds getting very tame with hunger; rooks dying. *Pennington* (C)—23rd. Winter aconite in flower. *Chislehurst* (C)—17th. Winter aconite in flower. *Churt Vicarage* (C)—16th. Picked a more than half-opened bloom off a tea-rose (Rubens) from south-east wall of Vicarage. *Lexden* (E) —16th. Winter aconite in flower.

FEBRUARY.—*Marazion.*—The frost has destroyed a very large portion of the broccoli crop. The extra hands engaged at the railway station for the broccoli season have all been discharged, as their services will not be required. Large numbers of birds have been killed, those which suffered most being redwings, thrushes, missel-thrushes, and starlings. Many golden plover and peewits have also succumbed. *Mawnan Smith* (A)—Hollies and bays suffered terribly from cold winds. Piles of dead wild birds brought out of rat holes by ferrets after cold weather. 14th. Our cold has been mostly in wind. Redwings and thrushes were the only birds found in this garden helpless or dead. *Falmouth* (A) —Very strong Easterly wind. Shrubs exposed to its full force seemed literally burnt up, for instance, gorse and escallonia. Bay and laurestinus also suffered considerably. *Liskeard* (A)—13th. No thrushes heard, until to-day, since January 4th. *Sidcot* (A)—North and North-easterly winds were cruelly keen, and fairly burnt up the evergreens. Several dead thrushes lying about. *Long Ashton* (A)—Gorse almost everywhere killed near Lynton. *Castleton* (A)—Shrubs much damaged by frost, some dead, and others only now (April) slowly recovering. *St. Arvan's* (A)—All winter greens destroyed by the frost. 28th. Winter aconite in flower. *St. David's* (A)—Much gorse and many shrubs have entirely perished. Dead birds (starlings and others) lying about by hundreds. Woodcock, snipe, and lapwings entirely absent. *Aberystwith* (A)—Evergreens have suffered much and look wretched. All resident birds, except buntings and finches, much reduced in number. Probably nine-tenths of the thrushes killed. Very few hares left. *Killarney* (B)—17th. Great flocks of sea birds haunted the houses, tamely feeding inside our doors—gulls, guillemot, and curlew. *Ferns* (B)—Escallonia, bay, Portugal laurel, and even common laurel killed. *Woodenbridge* (B)—Shrubs suffered greatly in exposed positions. *Glendalough* (B)—Immense injury was done here to trees by the snow. Nearly every Scotch fir, oak, and birch on the shady side of the valleys had their boughs torn off. In places the oak woods were half destroyed—greatest destruction in living memory. *Geashill* (B)—Gorse blighted to a large extent. Bays and laurustinus killed. Mr. Digby (Lord Digby's agent), when the snow lay on the ground, on cutting down a large branch from a sycamore tree, noticed that the sap was flowing so copiously that he was obliged to move from under the branch to save himself from a shower-bath. *Carisbrooke* (C)—By the end of the month not a green leaf or grass blade was to be seen in the Isle of Wight, while gorse was in most places killed off. The various evergreen shrubs, for which the island is so famous, have been severely handled by the prolonged East wind, and present now (April) a miserable appearance everywhere. *Bembridge* (C)—All the veronicas killed. Fuchsias, rosemary, thyme, and sage also killed except in sandy soil. Bewick's and the Hooper swans seen as in winter of 1891-2. Cold cutting winds and no snow on ground. Scotch kale the only green vegetable not destroyed. *Buckhorn Weston* (C)—The gorse and a great deal of the laurustinus killed. Bays and laurels much injured. *Pennington* (C)—Vegetables spoilt, roots frozen and rotting. Thrushes and starlings dying from hunger. Winter birds scarce all the season. *Strathfield Turgiss* (C)—All growth at a complete standstill, and no insects or birds moving. *Chislehurst* (C)—Portugal laurel killed. *Coneyhurst* (C)—16th. The frost has done no great damage here. Of wild plants the heather and gorse suffered the most. *Churt Vicarage* (C)—Brussels sprouts destroyed. Evergreens, such as laurel, much injured on the south side, where the effects of

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1895.

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A											
Marazion	60	106	113	...	...	274	93	...	79	123	...
Mawnan Smith	*102*	101	119	...	...	...	77	...	94	123	...
Falmouth	...	90	105	...	138	291	...	...	100	123	*105*
Liskeard	4	101	108	...	137	...	64	113	101	142	...
Tiverton	...	...	...	...	...	...	100	...	...	...	...
Westward Ho	...	105	103	...	136	*258*	94	130	105	143	*196*
Sidcot	...	103	103	119	...	284	76	110	106	...	...
Long Ashton	20	...	113	...	...	...	20	117	...	...	...
Clifton	...	...	105	115	...	...	...	103	118	121	...
Penarth	...	...	105	...	...	...	72	124	109	112	161
Castleton	64	100	109	121	139	285	70	81	118	119	143
Bassaleg	57	100	106	109	140	282	47	92	117	...	...
St. Arvan's	59	99	107	124	129	273	63	85	124	131	170
St. David's	58	102	106	...	...	...	76	...	103	142	159
Aberystwith	70	101	111	...	131	...	98	106	107	123	...
B											
Cork	...	*122*	*122*	...	*174*	...	104	...	118	109	167
Killarney	20	107	108	...	...	276	71	103	97	119	148
Ferns	53	96	107	...	...	273	94	99	101	123	151
Woodenbridge	53	92	104	...	...	302	60	...	...	...	172
Glendalough	...	103	108	...	...	269	...	...	127	122	...
Geashill	...	...	*121*	...	123	...	...	121	121	129	175
C											
Carisbrooke	51	101	109	107	...	...	76	...	101	128	157
Bembridge	19	99	101	100	...	326	73	94	79	...	*100*
Whitchurch Canonicorum	...	107	107	101	...	...	92	66	93	...	...
Blandford	...	100	98	106	105	302	74	123	77	118	...
Buckhorn Weston	62	100	107	106	115	304	...	...	99	122	161
Pennington	...	106	107	108	127	...	81	109	120	...	171
Strathfield Turgiss	44	84	102	109	142	274	54	93	119	125	163
Bexhill-on-Sea	52	101	100	103	119	320	62	90	107	145	145
Muntham	68	100	100	104	130	285	59	122	91	129	...
Dover	...	113	...	...	...	313	...	...	...	...	...
Swanley	...	118	97	99	...	...	...	125	110	...	156
Chislehurst	49	106	103	109	128	284	70	120	110	147	173
Coneyhurst	61	103	100	104	124	280	72	91	111	...	...
Churt Vicarage	19	103	103	...	111	284	70	126	90	147	163
Churt	55	103	100	104	127	283	70	...	97	126	155
Cranleigh	...	104	101	107	...	277	70	114	101	119	148
Winterfold	...	105	100	107	125	...	...	104	...	...	...
Willinghurst	61	...	99	107	...	...	...	72	...	...	...
Oxshott	58	112	107	107	...	283	...	...	...	...	...
Addlestone	57	96	103	100	*92*	282	77	80	104	133	...
East Molesey	16	109	*117*	113	...	285	66	102	102	131	...
Farley	77	...	102	107	...	...	74	109	...	...	...
Marlborough	18	100	105	...	139	...	...	...	103	131	159
Reading	50	102	108	104	...	...	...	105	130	...	...
D											
Oxford	...	100	104	...	...	...	74	...	104	...	...
Cheltenham	48	102	102	...	144	309	75	91	102	...	...

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1895—*Continued.*

STATION.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
Beckford	64	101	103	107	139	284	70	118	109	127	162
Watford	52	105	102	107	148	282	...	103	100	...	...
St. Albans (The Grange)	...	...	100	101	...	...	71	...	103	...	...
St. Albans (Addisc'be Lodge)	...	*118*	102	113	150	...	...	...	...	...	...
St. Albans (Worley Road)	50	101	97	107	...	...	...	...	...	...	...
Radlett	...	107	107	108	139	...	69	...	89	...	...
Berkhamsted	48	87	101	102	129	287	71	68	102	...	...
Harpenden	58	106	98	108	...	...	74	82	99	...	...
Ross	49	93	108	...	133	...	66	75	...	...	...
Breinton	.66	104	107	...	144	...	72	99	89	111	...
Leominster	...	98	105	115	119	...	...	123	114	...	...
Evesham	61	101	101	102	...	286	73	75	106	145	...
Ullenhall	*83*	107	109	116	132	...	74	108	106	116	177
Northampton	...	...	...	...	...	...	76	..	101	...	...
Churchstoke	66	108	111	...	...	278	78	...	...	143	167
Thurcaston	...	...	...	...	...	...	...	...	118	129	...
Uppingham	...	...	...	...	...	...	76	...	103	...	...
Tean	69	101	108	...	...	...	...	...	...	...	...
Beeston	33	106	109	...	130	282	76	128	120	...	...
Hodsock	66	101	110	109	133	287	52	99	109	127	...
Macclesfield	71	119	114	...	...	279	...	...	...	...	...
Belton	60	102	108	113	131	...	70	109	110	*157*	...
Harrogate	48	103	114	...	141	291	76	75	125	...	...
E											
Wormley	66	103	107	108	145	293	73	125	104	126	160
Hatfield	60	111	100	107	...	...	100	102	95	147	...
Hitchin	...	...	104	107	124	...	...	...	104	...	...
Ashwell	...	101	...	109	141	289	...	...	...	...	...
Bocking	...	113	114	*117*	...	...	81	...	...	...	...
Lexden	52	109	107	106	...	...	73	...	114	129	167
Sproughton	53	109	107	109	137	304	69	103	110	131	...
Tacolneston	...	107	108	109	...	...	71	110	110	...	...
Brundall	...	112	108	...	...	...	...	...	...	...	...
F											
Palé	67	102	109	...	129	265	...	...	*133*	131	180
Penmaenmawr	51	103	108	...	118	...	73	80	...	...	...
Claughton	...	...	113	...	...	...	...	...	...	...	...
Giggleswick	68	107	114	...	...	281	...	...	...	...	...
Ambleside	69	109	104	...	129	268	81	109	119	126	...
Cronkbourne	69	*125*	*130*	...	...	268	60	117	112	...	*102*
Orry's Dale	...	...	111	...	...	257	...	...	103	...	...
Sulby	72	105	105	...	...	276	91	95	108	...	150
G											
Edgeworthstown	...	102	...	...	158	272	82	...	105	...	...
Westport	76	104	121	...	...	280	...	...	...	...	...
Loughbrickland	54	101	114	...	...	272	92	54	103	131	...
Saintfield	66	106	115	...	136	284	66	105	113	126	...
Antrim	61	107	123	...	128	264	80	97	122	148	...
Londonderry	56	112	122	...	...	...	...	*138*	123	129	167
Ballynagard	...	104	114	...	...	288	...	105	111	126	171
Ramelton	...	100	112	...	...	...	..	120	..	129	...

TABLE V.—DATE (DAY OF YEAR) OF SONG AND MIGRATION OF BIRDS, AND FIRST APPEARANCE OF INSECTS, 1895—*Continued.*

STATION.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
H											
New Galloway	...	108	106	...	...	...	...	125	121	...	...
Tynron	...	112	117	...	...	...	71	*135*	117	...	...
Thornhill	...	110	114	...	...	...	75	122	...	...	...
Jardington	66	81	114	...	...	...	...	79	124	...	170
Helensburgh	51	114	112	...	...	...	103	124	118	...	...
I											
Great Cotes	...	103	105	...	129	313	...	...	...	...	...
Thirsk	56	102	100	...	142	282	72	97	100	142	...
East Layton	66	112	118	...	133	269	71	74	129	143	...
Durham	66	*126*	123	...	133	296	109	126	117	...	...
Cambois	54	117	119	...	...	293	110	110	105	...	...
Lilliesleaf	*121*	115	128	...	122	298	88	120	...	...	...
J											
Kirriemuir	...	...	...	...	...	279	...	...	...	...	...
Aberdeen	52	117	133	...	125	277	110	130	122	...	...
Newmill	...	127	122	...	...	261	...	121	125	128	151
Lhanbryde	...	...	125	...	...	...	33	107	118	...	...
K											
Beauly	...	132	120	...	119	...	...	...	123	117	189
Inverbroom	...	156	122	...	...	...	104	103	149	...	...
Mean Dates for the British Isles in 1895 .	54 Feb. 23rd.	105 Apl. 15th	108 Apl 18th	108 Apl. 18th	132 May 12th	284 Oct. 11th	76 Mar. 17th	108 Apl. 18th	108 Apl. 18th	129 May 9th	163 June 12th
Mean Dates for 1891-4	Feb. 1st.	Apl. 17th	Apl. 20th	Apl. 21st	May 13th	Oct. 13th	Feb. 26th	Apl. 4th	Apl. 9th	May 4th	June 10th

The dates in *italics* have not been taken into consideration when calculating the means for the British Isles.

alternate sun by day and frost by night have all but killed them. *Churt* (C)—Blackbirds, thrushes, larks, etc., have died in great numbers. *Cranleigh* (C)—Piercing North and North-easterly winds throughout the month. Fields of cabbages destroyed by the frost. *Winterfold* (C)—Gorse, heather, common laurels, and also all green vegetables, suffered most during the frost. *Addlestone* (C)—Common laurel, laurustinus, and Portugal laurel badly cut by frost. *Marlborough* (C)—Most of the winter greens were destroyed, and all species of berberis cut to the ground except berberis vulgaris. *Cheltenham* (D)—Among shrubs laurustinus, Portugal laurel, bay, and berberis Darwinii suffered most. Gorse brown and withered. *Beckford* (D)—Scores of birds were killed. Thrushes very scarce. *Watford* (D)—Every green vegetable killed. Laurels and bays have suffered greatly. *Berkhamsted* (D)—Much of the gorse on Berkhamsted Common has been killed to the ground. *Northampton* (D)—Shrubs suffered severely. *Thurcaston* (D)—Portugal laurels and bays were severely cut. Aucuba, yew, and cedar of Lebanon were also much injured.

TABLE VI.—ESTIMATED YIELD OF FARM CROPS IN 1895.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H W.	J E.	K N.	B and G S. and N.	
Wheat	Much U.A.	Much U.A.	Much U.A.	Much U.A.	U. Av.	U. Av.	U. Av.	U. Av.	...	U. Av.	Much U.A.
Barley	Much U.A.	Much U.A.	Much U.A.	Much U.A.	U. Av.	Av.	Av.	Av.	...	U. Av.	Much U.A.
Oats	Much U.A.	Much U.A.	Much U.A.	Much U.A.	U. Av.	U. Av.	U. Av.	U. Av.	...	U. Av.	Much U.A.
Corn Harvest began, average Date	215 (Aug. 3)	211 July 30	216 (Aug. 4)	213 (Aug. 1)	228 (Aug. 16)	228 (Aug. 16)	236 (Aug. 24)	238 (Aug. 26)	245 (Sept. 2)	230 (Aug. 18)	226 (Aug. 14)
Beans	U. Av.	Much U.A.	Much U.A.	Much U.A.	Av.	U. Av.	U. Av.	U. Av.	...	U. Av.	Much U.A.
Peas	Av.	Much U.A.	U.Av.	Much U.A.	Av.	Av.	...	U. Av.	...	...	Av.
Potatoes	Av.	U.Av.	Av.	Much U.A.	Av.	O. Av.	Av.	Av.	...	O. Av.	U. Av.
Turnips	U. Av.	Much U.A.	Much U.A.	Much U.A.	U. Av.	U. Av.	U. Av.	U. Av.	...	U. Av.	U. Av.
Mangolds	Much U.A.	Much U.A.	Much U.A.	U.Av.	U. Av.	Av.	Av.	Av.	...	Av.	Much U.A.
Hay (Permanent Pasture)	Much U.A.	Much U.A.	Much U.A.	Much U.A.	Much U.A.	Much U.A.	Much U.A.	Much U.A.	...	Much U.A.	Much U.A.
Hay (Clover, etc.)	Much U.A.	Much U.A.	Much U.A.	Much U.A.	Much U.A.	Much U.A.	Much U.A.	Much U.A.	...	Much U.A.	Much U.A.

The variations from the average relating to all the above crops have been obtained from the *Agricultural Gazette*, July 20, 1895.

TABLE VII.—ESTIMATED YIELD OF FRUIT CROPS IN 1895.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A. S.W.	C. S.	D. Mid.	E. E.	F. N.W.	I. N.E.	H. J. and K. W. E. and N.	B. and G. S. and N.	
Apples	O. Av.	O. Av.	O. Av.	Av.	O. Av.	Av.	Av.	Av.	O. Av.
Pears	Av.	U. Av.	U. Av.	U. Av.	Av.	U. Av.	U. Av.	U. Av.	U. Av.
Plums	Av.	U. Av.	U. Av.	U. Av.	Av.	Av.	O. Av.	Av.	U. Av.
Raspberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Currants	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Gooseberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Strawberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.

Symbols:—O. = Over. U. = Under. Av. = Average. This Table has been compiled from returns which appeared in the *Gardeners' Chronicle*, Aug. 3, 1895.

TABLE VIII.—APPROXIMATE VARIATIONS FROM THE AVERAGE IN MEAN TEMPERATURE, RAINFALL, AND SUNSHINE, 1894-5.

WINTER 1894-5.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
December . .	+3·5	+3·8	+3·0	+3·5	+3·3	+3·3	+3·8	+3·8	+3·0	+2·0	+2·8
January . .	-6·0	-6·2	-5·6	-6·6	-5·8	-6·0	-5·4	-6·8	-5·6	-6·8	-6·6
February . .	-10·3	-8·3	-10·8	-11·3	-9·5	-9·8	-8·3	-9·5	-8·0	-9·8	-7·3
Winter . .	-4·3	-3·6	-4·5	-4·8	-4·0	-4·2	-3·3	-4·2	-3·5	-4·9	-3·7
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December . .	-0·2	+0·2	-0·3	-0·2	-0·2	+0·3	+0·4	-0·4	-1·0	-0·1	+1·9
January . .	-0·1	-0·3	-0·2	+0·7	+1·1	-0·6	-0·7	-4·9	+2·6	0·0	-2·6
February . .	-2·8	-1·7	-1·8	-1·9	-1·4	-2·0	-1·2	-3·1	-0·8	-1·6	-2·8
Winter . .	-3·1	-1·8	-2·3	-1·4	-0·5	-2·3	-1·5	-8·4	+0·8	-1·7	-3·5
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December . .	+ 2	- 5	+ 6	+ 3	- 3	+ 3	-11	- 2	+ 2	-12	+ 2
January . .	+33	+10	+12	+10	-10	+19	+19	+36	+ 6	-18	+ 8
February . .	+23	+15	+19	+26	+26	+23	+19	+17	+44	+18	+27
Winter . .	+58	+20	+37	+39	+13	+45	+27	+51	+52	-12	+37
SPRING 1895.											
Temperature.											
	°	°	°	°	°	°	°	°	°	°	°
March . .	-0·3	+0·3	-0·5	+0·3	+0·8	-0·8	+0·5	+0·3	+1·0	+0·3	+0·5
April . .	+0·8	+0·5	+0·8	+1·0	+1·0	0·0	+0·8	+1·0	+1·3	+0·8	+0·8
May . .	+2·0	+1·2	+2·0	+2·8	+2·0	+2·4	+2·2	+2·4	+2·0	+2·8	+3·2
Spring . .	+0·8	+0·7	+0·8	+1·4	+1·3	+0.5	+1·2	+1·2	+1·4	+1·3	+1·5
Rain.											
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March . .	+0·7	+0·9	0·0	+0·1	+0·2	+1·2	+0·9	+0·3	+0·3	+0·5	+0·6
April . .	-0·1	-0·6	0·0	+0·2	-0·5	+0·2	-0·3	-0·2	-0·5	-0·5	+1·1
May . .	-1·8	-1·5	-1·7	-1·6	-0·8	-1·3	-1·7	-2·3	-1·0	-1·3	-1·3
Spring . .	-1·2	-1·2	-1·7	-1·3	-1·1	+0·1	-1·1	-2·2	-1·2	-1·3	+0·4
Sunshine.											
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March . .	- 2	-15	- 2	-11	+ 7	-23	-17	-29	-19	-15	+ 3
April . .	-11	-33	-23	+ 5	- 7	+ 6	- 8	-20	+22	+37	-35
May . .	+79	+16	+41	+63	+39	+34	+31	+18	+25	+24	- 1
Spring . .	+66	-32	+16	+57	+39	+17	+ 6	-31	+28	+46	-33

+ indicates above the average, – below it.

TABLE VIII.—Variations from the Average—*Continued.*

Summer 1895.

Months.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
					Temperature.						
	°	°	°	°	°	°	°	°	°	°	°
June	+1·5	+1·3	+0·8	+0·8	0·0	+0·3	+1·3	+1·3	+0·5	+0·5	+0·5
July	−0·6	−1·6	−0·6	−1·0	−0·6	−1·4	−1·0	−1·2	−0·8	−1·4	−1·0
August	−0·3	0·0	+0·8	+1·0	+1·3	+0·8	+0·8	+1·5	+2·3	+2·3	+2·0
Summer	+0·2	−0·1	+0·3	+0·3	+0·2	−0·1	+0·4	+0·5	+0·7	+0·5	+0·5
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June	−1·1	−0·9	−1·0	−0·9	−1·4	−1·0	−1·0	−1·7	−0·2	+0·3	+0·6
July	+0·8	+1·9	+1·5	+0·8	+1·4	+1·0	+1·7	+0·6	+1·7	+0·8	+0·3
August	+0·1	+0·5	0·0	−0·5	+1·2	+0·2	+1·5	+2·3	+0·1	+1·3	+1·9
Summer	−0·2	+1·5	+0·5	−0·6	+1·2	+0·2	+2·2	+1·2	+1·6	+2·4	+2·8
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June	+66	+65	+51	+52	+35	+61	+79	+49	+40	+42	+33
July	−15	−47	−21	−11	−4	+7	−42	−21	−11	−14	−37
August	−4	−43	+50	+28	+45	−2	−28	−22	+6	−5	+10
Summer	+47	−25	+80	+69	+76	+66	+9	+6	+35	+23	+6
					Autumn 1895.						
					Temperature.						
	°	°	°	°	°	°	°	°	°	°	°
September	+4·3	+2·8	+4·5	+4·8	+3·8	+4·3	+4·5	+3·8	+4·3	+4·3	+4·0
October	−0·2	−0·2	−0·2	−0·2	−0·2	−0·2	−0·2	−0·3	−0·3	−0·3	−0·3
November	+0·4	+0·1	+0·5	+0·4	+0·4	+0·2	+0·2	+0·2	+0·3	+0·1	+0·1
Autumn	+1·5	+0·9	+1·6	+1·7	+1·3	+1·4	+1·5	+1·2	+1·4	+1·4	+1·3
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September	−2·9	−2·3	−1·7	−2·0	−1·7	−1·8	−2·2	−2·8	−1·8	−1·7	−0·3
October	+0·6	−0·6	+0·1	−0·6	0·0	+0·5	+0·8	−1·2	+1·4	+0·7	−0·2
November	+1·8	+2·2	+1·8	+1·5	+0·5	+0·2	+0·6	+0·2	−0·2	+0·3	+0·1
Autumn	−0·5	−0·7	+0·2	−1·1	−1·2	−1·1	−0·8	−3·8	−0·6	−0·7	−0·4
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September	+59	+50	+88	+81	+90	+58	+40	+40	+89	+35	−37
October	+17	+36	+5	+7	+3	+28	+48	+32	+44	+49	+16
November	0	+16	−8	−5	+1	+4	+18	+6	−9	+1	+11
Autumn	+76	+102	+85	+83	+94	+90	+106	+78	+124	+85	−10

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

Beeston (D)—Great damage caused to hollies, gorse, etc., by rabbits during the frost. *Hodsock* (D)—Most laurels had to be cut down, but some have survived. Some shrubs, such as yews and cupressus Lawsoniana, which we have never known injured before, look very brown, although not killed, while other kinds of trees are not as much injured as in previous winters. *Wormley* (E)—The gorse has suffered very much. *Bocking* (E)—Here no shrubs, even of tender kinds, seem to have been absolutely killed, though some lost many, or most of their leaves. *Lexden* (E)—Of shrubs which were very nearly or quite killed may be mentioned veronica, euonymus, bay, gorse, and yellow broom. Thrushes, fieldfares, rooks, and blackbirds felt the loss of food severely, and several had either one foot or both feet frozen. *Tacolneston* (E)—6th. Bees were tempted out by the warm sun, and died in numbers. *Palé* (F)—Portugal laurels suffered more than any other shrub last winter, but in 1881 were uninjured. Exactly the opposite has happened to the common laurel, which in 1881 was killed to the ground. *Penmaenmawr* (F)—9th. Jackdaws killing and eating half-starved larks. *Claughton* (F)—Some of the large Portugal laurels are looking dead, and many nearly so, from effects of frost and blizzard. *Giggleswick* (F)—Evergreens suffered badly from long winter and late snow. *Ambleside* (F)—Hundreds of shrubs were killed all over the place, especially where they were exposed to sunshine during the day. Many birds were found dead or dying on the ice, and amongst them gulls and snipe. *Cronkbourne* (F)—Escallonia, sweet bay, and many laurustinus were killed to the ground. Numbers of blackbirds, thrushes, etc., have been found dead. *Sulby* (F)—6th. The severest snowstorm ever experienced in the Isle of Man within the memory of any living person commenced on this day. *Edgeworthstown* (G)—Much damage done to shrubs of all kinds. Laurels killed in many places. *Westport* (G)—Cold felt very much by birds, particularly starlings, which died in thousands. *Loughbrickland* (G)—The frost killed all the gorse (except where protected by heavy drifts of snow) down to the ground. *Saintfield* (G)—Gorse killed by frost. *Antrim* (G)—Tender shrubs have been cut to the ground, and some killed outright. Portugal laurels were stripped bare, and are now (April) budding again. Saw blackbirds, gulls, coots, and grebes lying dead. *Ballynagard* (G)—Sea-gulls came in dozens round the doors for food, and even ventured on to the window-sill. *Ramelton* (G)—Fuchsias 8 feet high killed. Irish and other yews greatly blackened and injured. Leaves blown off all the hollies. A great deal of gorse killed. *Tynron* (H)—Laurels and coniferous trees, such as Thuja borealis, almost killed. *Great Cotes* (I)—The greater part of our thrushes were carried off by the severe winter, and those surviving were very thin and out of condition. *Thirsk* (I)—Gorse quite brown and apparently killed. Very few blackbirds or thrushes, but numerous chaffinches. The red deer in Duncombe Park have escaped over the high fences, and are now wandering about the country. Many are lying dead in the park and in the woods around. A great many wild swans have been shot in the district. *East Layton* (I)—Laurels almost exterminated. Yews and other evergreens much injured. *Lilliesleaf* (I)—Laurels and rhododendrons have suffered a good deal. *Aberdeen* (J)—Many shrubs, such as cupressus Lawsoniana, pernettyas, retinosporas, cryptomerias, and araucarias have been killed outright. *Newmill* (J)—All evergreens above the snow were very much injured, especially laurels and hollies. Trees were also split by the action of frost. *Beauly* (K)—Many araucarias, hollies, berberises, gorse bushes, and brooms killed outright. Portugal laurels were much injured, but have since (April) recovered.

MARCH.—*Penarth* (A)—The severe winter did not seem to affect insects much, except delaying the appearance of March species a few days. *St. Arvan's*—24th. Very strong Westerly gale. *Aberystwith* (A)—4th. Frog spawn. *Buckhorn Weston* (C)—26th. Hazel never so late in flowering since 1880. *St. Albans* (*The Grange*) (D)—24th. One of the most destructive gales to trees

which has ever passed over Hertfordshire. *Beeston* (D)—24th. The gale whirled many rooks' nests out of the trees, but they were rebuilt within 48 hours as a rule. *Hitchin* (E)—23rd. Cyclonic storm brought down a large number of trees. Saw myself four elms uprooted in a quarter of an hour, and counted 36 trees blown down in a comparatively small area. *Ashwell* (E)—24th. Very high wind, many trees uprooted, principally between 1·30 and 2·30 p.m., with shift of wind from South to South-west and West. *Tacolneston* (E)—15th. Ice still not entirely gone from shaded ponds, and considerable remains of snowdrifts in deep ditches here and there. *Brundall* (E)—24th. Great Westerly gale. On some estates near Norwich hundreds, and on others thousands, of fine trees were laid flat, and in many cases whole plantations were left with hardly a tree standing. It is no exaggeration to say that in the county of Norfolk the number of large trees uprooted must have far exceeded 100,000.

APRIL.—*Falmouth* (A)—Trees, etc., were slow to come out this spring, but having once begun, seemed to grow very quickly indeed. *Tiverton* (A)—3rd. I was struck by the look of the lanes: the banks of periwinkles generally green all the winter are now covered with withered trails. *St. Arvan's* (A)—30th. Corncrake heard. *Ferns* (B)—12th. Snow several inches deep still to be seen in many of the ditches. *Buckhorn Weston* (C)—Noticeable absence of aphides. *Strathfield Turgiss* (C)—The nesting of all birds very late. Birds of all kinds scarce, many having died during the frost. *North Cornwall*—In all this district (an elevated one between 400 and 800 feet high) April and May usually acquire a glory all their own, from the flowering of gorse on the sides of the roads, moors, wastes, etc. This year we looked upon space after space, acre after acre, mile after mile, covered with brown, withered-looking stems and prickles. Scarcely a flower to be seen and nothing green. A friend residing on this property, seventy-six years of age, told me it was the only season which had produced such a result in his recollection, and he is a keen observer of nature. (C. U. Tripp, Addlestone). *Cheltenham* (D)—Remarkable absence of aphis. Very few flowers on blackthorn. *Berkhamsted* (D)—23rd. Wild cherry in blossom—its average date for previous nine years. *Lexden* (E)—Slugs numerous. *Saintfield* (G)—Very little blossom on blackthorn. *Antrim* (G)—Have not seen a single missel-thrush. *Ballynagard* (G)—29th. Swift first seen. *Ramelton* (G)—24th. Corncrake first heard. Very few wasps.

MAY.—*Marazion* (A)—6th. Swifts first seen. *Mawnan Smith* (A)—20th. Plenty of queen wasps. Nothing like the show of the last two years on the blackthorn. 28th. Hollies still completely bare of leaves in our garden (on a hill). *Falmouth* (A)—Primroses never finer or more abundant, also wild hyacinths. *Tiverton* (A)—22nd. Hawthorn, although late in opening, now as full of flowers as usual at this date. *Sidcot* (A)—Destruction from winter frosts not nearly so great as feared. Pampas grass, several brooms, a fine passion flower on the side of a house facing west, and arbor vitæ, were killed outright; but all our laurels, aucubas, escallonia, laurustinus, etc., which looked utterly scorched up, as if they had no life left in them, seem now renewing their youth; also evergreen oaks and arbutus have now shed their dead leaves, and are being covered with young shoots. Blackthorn and hawthorn blossom very scarce, also plum blossom. Nightingales unusually plentiful this year. *St. Arvan's* (A)—3rd. Swifts seen. Snails and slugs more plentiful than usual. *Killarney* (B)—Few white butterflies, but many queen wasps. *Whitchurch Canonicorum* (C)—Very few wasps or aphides this spring. *Pennington* (C)—Hawthorns blooming sparsely. A great deal of hard pruning necessary amongst such shrubs as bay, laurustinus, escallonia, and especially Darwin's berberis. Great contrast between green trees and brown flowerless gorse. 3rd. Swift seen and corncrake heard. *Bexhill-on-Sea* (C)—The slug, grub, and wireworm abound this spring. *Farnborough* (C)—The winter frosts have killed all the gorse on the common.

Chislehurst (C)—Hardly any flower-seeds come up owing to drought. *Churt Vicarage* (C)—7th. Large number of queen wasps about. 31st. The extent of damage done by the February frost can now be estimated. Gorse bushes and heather much injured, and in many places destroyed. *Churt* (C)—Nightingales in unusual numbers. *Oxshott* (C)—Common furze seems almost destroyed. *Cheltenham* (D)—Very few flowers on hawthorn. *St. Albans* (*Worley Road*) (D) —6th. Swift first seen. *Tean* (D)—10th. Swift first seen. *Berkhamsted* (D)—7th. Blenheim orange apple in blossom one day behind its average date for previous nine years. *Beeston* (D)—18th. A wonderful amount of bloom on elms. *Hodsock* (D)—Very few blackbirds and thrushes to be seen. *Lexden* (E)—6th. First swift seen. *Sproughton* (E)—31st. Began to cut my hay, the earliest date I can remember. *Brundall* (E)—16th. Storms of hail and sleet. The results were apparent to the end of the month, the north sides of the trees being covered with brown shrivelled leaves as in November, while on the south side the bright green May foliage was intact. *Palé* (F)—The winter snow was still to be seen in the hollows of the Berwyn mountains during the first week of this month. *Penmaenmawr* (F)—The smaller insectivorous birds appear to have felt the severe winter frosts the most. *Claughton* (F)—Blackthorn has flowered badly. *Londonderry* (G)—Very little blossom on blackthorn. *Tynron* (H)—Have not heard the song-thrush this year, nor observed any promise of hawthorn blossom. *Helensburgh* (H)—25th. Greenfly quite a plague here, and owing to dry weather has done much damage to trees, etc.

JUNE.—*Marazion* (A)—1st. No wasp has been seen up to this date. *St. Arvan's* (A)—2nd. Very little blossom on hawthorn. 28th. Roses free from aphides. *St. David's* (A)—Foliage of trees unusually heavy. *Glendalough* (B) —Butterflies unusually scarce. Have seen greenfly on only one plant. Scarcely any flowers on the hawthorn this year. 14th. Potatoes in low-lying land suffered much from frost. *Pennington* (C)—Roses very free from blight. 7th. Began cutting grass for hay, all carried by 24th. *Chislehurst* (C)—Some hawthorns have no flowers at all. Thrushes and blackbirds quite as plentiful as usual. *Churt Vicarage* (C)—13th. Vegetable marrows destroyed and potatoes and French beans injured by frost in lower parts of parish. 27th. Plants are being forced prematurely into bloom. *Churt* (C)—Never saw the wheat looking so poor and thin. *Cheltenham* (D)—Very few butterflies, but a great many wasps. *Beckford* (D)—Very little greenfly. *Radlett* (D)—Very little hawthorn blossom in the hedges. Caterpillars did much damage to roses and lime trees. *Berkhamsted* (D)—15th. A good deal of the young bracken killed by frost on Berkhamsted Common. *Harpenden* (D)—8th. First ear of wheat observed fully out. *Ullenhall* (D)—Very few thrushes to be seen this year. *Tean* (D)—14th. Frost killed potatoes, kidney beans, and blackened ferns and young leaves of ash trees. *Macclesfield* (D)—1st. Common hollies have had most of their leaves killed by winter frost, and are now almost bare. 15th. Dahlias and kidney beans killed by frost. *Wormley* (E)—Very little hawthorn blossom this year. *Hatfield* (E)—Great damage done by caterpillars in the woods here, some of the oaks almost bare as in midwinter. *Ashwell* (E)—15th. Sharp frost, scarlet runners and potatoes injured in places. *Lexden* (E)—No diminution observable in the number of moths, early butterflies, beetles, slugs, and the smaller insects, with the exception of aphides. *Palé* (F)—15th. Ferns were killed to the ground on banks facing the sun by the frost; the tender tops of the trees were also injured. Never remember such damage done by frost in June. *Claughton* (F)—10th. French beans and potatoes nipped by frost. *Loughbrickland* (G)—12th. Frost injured potatoes and dahlias. *Antrim* (G)—12th and 13th. Potato crop greatly injured by frost, except on higher ground. *Londonderry* (G)—Very little blossom on hawthorn. *Ramelton* (G)—Very little hawthorn blossom. Very few wasps. *Tynron* (H)—15th. Early potatoes cut

to the ground by frost. Walnut leaves injured. Injury greatest to plants exposed to the rays of the morning sun. *Jardington* (H)—Hawthorn blossom not nearly so abundant this year. 15th. Potatoes on low-lying ground frosted. *Durham* (I)—Wasps exceptionally plentiful. Thrushes scarce, but blackbirds do not seem to have been affected. 13th and 15th. Potatoes and dahlias blackened in some of the low parts near the river. *Lilliesleaf* (I)—13th and 14th. Potatoes blackened. *Newmill* (J)—Queen wasps are very numerous. White butterflies plentiful. *Inverbroom* (K)—12th. Snow down to 1200 feet, and on 18th to 800 feet above sea-level.

JULY.—*Mawnan Smith* (A)—27th. Harvest begun. *Buckhorn Weston* (C)—Several of the orchids missing from their habitats for the last two or three years have bloomed this year. *Churt* (C)—All kinds of moths most abundant. *Berkhampsted* (D)—24th. My lawns were the colour of the gravel paths a week ago, but are now quite green again. *Beeston* (D)—A large crop of mushrooms in the fields. Not many wasps. *Newmill* (J)—Red admiral butterflies more numerous than usual.

AUGUST.—*Mawnan Smith* (A)—31st. Harvest quite over and corn carried. *Barnstaple* (A)—31st. The number of species of wild plants observed in flower to this date 567, at the same date in 1894, 524. *Woodenbridge* (B)—17th. Swifts left. *Pennington* (C)—5th. Cut first wheat and oats. Very few wasps this summer. *Strathfield Turgiss* (C)—Butterflies of all kinds scarce this summer. *Churt* (C)—Blackberries plentiful and fine. Wasps scarce, also butterflies. *Berkhamsted* (D)—22nd. The foliage of roses, dahlias, and chrysanthemums pierced and torn, and the stems much bruised by hail. In some cases the flower-buds were cut clean off. *Northampton* (D)—Owing to drought before the end of the month the leaves of the beech and other trees were beginning to fall. *Hodsock* (D)—7th. Harvest began. Very few wasps, although a great many queen wasps in the spring. Leaves falling from the beech and sycamore. *Antrim* (G)—12th. Swifts last seen. *Jardington* (H)—I never remember the grass growing so quickly.

SEPTEMBER.—*Marazion* (A)—2nd. Butterflies of all species are very scarce. *Mawnan Smith* (A)—2nd. Blackthorn in flower. *Tiverton* (A)—28th. Wild strawberries ripe, apple tree in blossom and fruit. Rosa arvensis in flower. *St. Arvan's* (A)—8th. Not so many wasps as usual. 27th. Dahlias blackened by frost. *Cork* (C)—12th. Grass very luxuriant now. *Bembridge* (C)—Delphiniums and other herbaceous plants flowering again. *Buckhorn Weston* (C)—Blackberries scarce, as so many brambles were destroyed by winter frost. *Pennington* (C)—Very few wasps. *Beckford* (D)—30th. Ripe strawberries gathered. *Watford* (D)—23rd. Dahlias killed. *St. Albans* (*The Grange*) (D)—The crane fly unusually abundant since the end of August. *Beeston* (D)—Butterflies very numerous. 25th. Raspberries ripe. *Hodsock* (D)—11th. Harvest finished. *Bocking* (E)—Wasps unusually numerous. *Jardington* (H)—Wild roses, strawberries, and apples are blossoming again. *Thirsk* (I)—Wasps very scarce. An exceptionally good crop of hazel nuts. *Cambois* (I)—Red admiral butterflies numerous, very unusual here.

OCTOBER.—*Sidcot* (A)—In the middle of October the hedges were full of dogwood flowers, together with many wild roses. Leaves long in changing their colour, but were unusually brilliant when they did change, and the trees very full of foliage. Heavy gales brought them down unusually soon. 7th. Gathered sprig of hawthorn in full flower. 22nd. Slight frost and snow on ground. 24th. Dahlias killed. *Woodenbridge* (B)—10th. The main body of swallows left. *Glendalough* (B)—22nd. Snow low down on hills from 22nd to 31st. *Bembridge* (C)—19th. Elms and other large trees still green where the foliage had not yet changed. *Buckhorn Weston* (C)—Both the dog and field roses have been in bloom again, also dogwood, and one tree of laburnum has been covered

with blossom. *Churt Vicarage* (C)—1st. Some apples and pears very large. Gathered an apple (Warner's King) weighing 19 oz., and a pear (Catillac) 22 oz. 30th. Dahlias killed. *Churt* (C)—Holly berries scarce. *Berkhamsted* (D)—28th. Last rose of the year gathered. *Harpenden* (D)—Ripe strawberries gathered. *Ross* (D)—The autumn flowers, which were very fine and luxuriant on the 16th, were completely spoiled by the severe frost of 17th, and the exceptionally severe frost continuing to end of month prevented any recovery. *Northampton* (D)—Raspberries and strawberries were gathered ripe in some quantities. *Beeston* (D)—15th. Strawberries in bloom and some ripe berries. *Hodsock* (D)—The autumn tints have not been bright. *Macclesfield* (D)—Very few limes shed their leaves until the first week in this month, when gales nearly stripped many deciduous leaves. *Palé* (F)—The weather was so cold the farmers had to house the cows at night. *Durham* (I)—1st. Gathered a wild rose. 4th. Redwings appeared. 12th. Fieldfares seen. 18th and 19th. Dahlias killed by frost. *Inverbroom* (K)—28th. Snow two feet deep. 29th. Snow bunting seen.

NOVEMBER.—*Mawnan Smith* (A)—9th. Autumn tints in sheltered places more beautiful than usual. Wind stripped trees early on the hills. 30th. One bush of rhododendron quite crimson. *St. Arvan's* (A)—3rd. The elms have scarcely turned colour yet. 24th. Nearly all trees lost their leaves. *Killarney* (B)—10th. Foliage has remained unusually green, only now any decided fall of leaf setting in. Acorns, walnuts, horse and Spanish chestnuts abundant. Beech nuts very scarce. Admiral butterfly has been very numerous. French beans and dahlias as yet scarcely touched by frost. *Bembridge* (C)—8th. Many swallows to be seen. 22nd. Five swallows seen flying and hovering around the ivy at the golf club-room—no doubt young birds. *Chislehurst* (C)—10th. Leaves very late in falling, mostly came off during to-day's gale. *Cheltenham* (D)—The heat and drought have ripened the wood splendidly. *Watford* (D)—No holly berries here this season. *Harpenden* (D)—A characteristic of this season was the second flowering of many fruit-trees and wild plants. Ripening apples and blossoms on the same tree. *Giggleswick* (F)—Trees retained their leaves rather longer than usual this year. *Ambleside* (F)—19th. Forty-three different kinds of wild plants were gathered. *Cronkbourne* (F)—30th. Ripe strawberries and raspberries gathered. *Lilliesleaf* (I)—No holly berries at all. Autumn tints not very good, but the leaves remained green on the trees a long time. *Newmill* (J)—7th. Autumn tints very fine.

DISCUSSION.

Mr A. BREWIN said that he had noticed that the effect of frost on plants and shrubs in some winters differed greatly from that in others, though the frosts were equally severe. He thought that the direction of the wind, and the percentage of relative humidity, should be taken into consideration, as well as the temperature of the air.

Dr. C. T. WILLIAMS said that he was greatly interested in Mr. Mawley's Report. He also was surprised by the damage caused by the remarkable frost at the beginning of last year. Hardy shrubs were killed, and in the spring the gorse on the Surrey commons, instead of being green, presented large brown masses, which in the summer weather were very liable to catch fire. He had seen on Hindhead 40 to 50 acres of gorse in a blaze; and indeed almost every day there was a conflagration in the neighbourhood, one being opposite his own house; the fire was best extinguished by having sand thrown on it. He could corroborate Mr. Mawley's statement with regard to the second flowering and fruiting of plants and trees in the autumn, as he had in his garden two pear

trees which blossomed a second time, and the fruit reached a fair size in November. This was perhaps the more remarkable because the trees had been infested in the summer with insects, which the drought had made so numerous. The long dry summer, and the insect pests caused thereby, must have influenced the crops to no small degree. The appearance of such numbers of gulls in the Thames, too, was most uncommon, though a few came up most winters. He bore testimony to the great value of Mr. Mawley's curves for the thirteen plants, which he thought, considering the nature of the winter, agreed with the mean curve wonderfully well.

Dr. R. BARNES, referring to Dr. Williams' remarks on the destruction of gorse, did not think that it was killed outright. The branches and shoots were destroyed, but there must have been some vitality remaining in the lower stems so that they recovered, for on the Hampshire Downs round Liphook there were square miles now in full bloom. The present mild winter had also caused the hazel and the silver birch to throw out their catkins remarkably early.

Mr. R. H. SCOTT thought that the question of the remarkable appearance of gulls in the Thames could be answered by the fact that they found more food there than anywhere else. In fact there were numbers at St. James's Park at the present time.

Mr. H. SOUTHALL, in congratulating Mr. Mawley on his Report, said that the results contained therein agreed very well with his own observations. The destruction of shrubs on the whole during the frost was not so great as he had expected. It was specially remarkable that while several kinds of hardy shrubs suffered, some rather tender southern species were scarcely affected. The plants that were most commonly cut were cistus (or sun) roses and New Zealand plants of the *veronica* type. He did not think the injury done was due to the severity of the frost alone. Sudden frosts with high humidity were especially harmful. That of 1860-61 was a good example, when, after being mild till the middle of December, the thermometer fell to zero on Christmas day. In that frost the damage was greater than in the frost of last year. In his opinion a frost coming on suddenly with great moisture, and changing rapidly, did more damage to vegetation than a continuous frost. He thought that the inclusion of the *Tussilago fragrans* in the list of plants would be an acquisition as exhibiting earlier flowering than any of the others.

Mr. C. HARDING remarked on the high value of Mr. Mawley's curves for the various plants, and he thought that reliable and interesting results were now being obtained in this direction. He was glad that Mr. Mawley had adopted the districts used by the Meteorological Office, as these embraced a very fine set of meteorological observations, extending over a period of 33 years. He thought Mr. Mawley's Reports made the Meteorological Office's results even more valuable. With reference to the effect of the great frost of last year on vegetation, he mentioned that after a fall of snow, during the early part of the frost, he had swept a pathway to his thermometer screen and rain-gauge; the grass was then green, but after a time it turned quite brown, while that portion protected by the snow covering was not affected.

Mr. G. J. SYMONS, referring to the destruction of trees by the great gale of March 24, 1895, mentioned by Mr. Mawley, said that he believed that the centre of that storm passed across the Midlands near Rugby, from west to east, and that the damage to trees, buildings, etc., was greater than that of any gale of late years. It was to be regretted that no details had been presented to the Society.

Captain D. WILSON-BARKER said that the Report was very interesting as bearing on biology. As a rule the various sciences were accustomed to divide themselves by a too arbitrary line. He thought that the relation of one science to another should be studied. With regard to the absence of insects, he, unlike Mr. Mawley, had found plenty of aphides, but agreed with him as to the scarcity

of butterflies. The gulls mentioned by Mr. Scott as being in the neighbourhood of London at the present time were the small gulls which were constantly seen inland. The large gulls came up the Thames in great numbers during the great frost.

Mr. E. MAWLEY, in reply, said that it was often difficult to understand why certain plants, which had passed almost uninjured through one severe winter, should have been killed outright during another, in which the cold was neither as prolonged nor so intense. He, however, agreed with Mr. Southall in thinking that the difference in the condition of the plants themselves, at the time they were subjected to the action of severe frosts, would be found in most cases to have been the principal reason. As a remarkable instance of second fruiting, he mentioned having seen at a recent meeting of the Royal Horticultural Society a dish of green apples of fair size, which had been gathered early in January last. The returns sent in showed that in some localities caterpillars and other insect pests had proved very destructive. But taking the British Isles as a whole they were far less numerous than usual. According to Miss Ormerod's Report there was no conspicuous outbreak of any class of farm pests during the year. No doubt the Winter Heliotrope, *Tussilago* (*Petasites*) *fragrans*, was very early flowering, but he did not consider that it ought to be included in the list of plants to be observed, for it was not a native British plant, and was only to be found here and there throughout the country.

NOTES ON THE UNUSUALLY HIGH BAROMETER READINGS IN THE BRITISH ISLES—JANUARY 1896.

BY ROBERT H. SCOTT, M.A., F.R.S.

Secretary of the Meteorological Office.

[Read February 19, 1896.]

HAVING received a request from our President to place on record in the pages of our Journal some notes of the remarkable anticyclone of the second week in January, when the isobar of 31·0 in. for the first time appeared on our *Daily Weather Charts*, I at once complied with his desire, and have further ventured in these notes to allude also to the pressure at the end of the month, when a reading of 30·96 in., only 0·04 in. below that of 31 in., was observed at Roche's Point at 11 p.m. on the 29th. Two such phenomenal occasions in one month well deserve mention!

A peculiarity of these anticyclones was the circumstance that neither of them was associated with severe cold in these islands, though January is our coldest month. As will be seen from Fig. 1 there was on the morning of the 9th no temperature much below 32° at any station, except over one or two of the inland parts of Scotland. So that in this respect the same conditions prevailed as in the anticyclone of January 1882, of which an admirable account by Mr. H. Sowerby Wallis appears in the *Quarterly Journal*, vol. viii. p. 146.

The interest about the two anticyclones now under notice is enhanced by the fact that both of them came on us in great measure from the Atlantic, and not from the continent of Europe. In the first case the highest readings were registered in the north-west on the 9th, and in the second in the south-west on the 30th.

Dealing first with the earlier system,—In the *North Atlantic Pilot Chart* for February, the view that the anticyclone was purely an Atlantic one is strongly put forward, and a track is given, commencing abruptly at Stornoway on the evening of January 8th, with a reading of 31·01 in., and passing south-westwards with diminishing intensity, until on the morning of the 13th its centre is placed about long. 30° W. and lat. 45° N., and the central reading is only 30·70 in. The track finally ceases on the 15th in long. 20° W. and lat. 40° N., with a reading of 30·55 ins.

I think that the maps in the *Daily and Weekly Weather Reports* will not give complete support to the track in the *Pilot Chart*, as we are able to show that an anticyclone of very respectable intensity had been moving

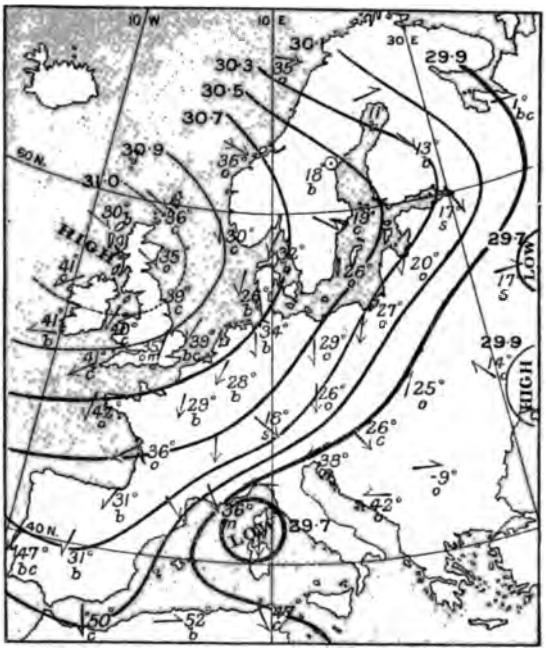


FIG. 1.—Weather Chart, 8 a.m., January 9th, 1896.

out over us from the eastward for some days prior to the 9th, though undoubtedly it was not until the western and north-western stations began to feel its influence that the barometer approached the unusual height it afterwards attained. If we may draw an analogy from sea waves, it looks as if the westward moving cyclone had met and coalesced with an independent system lying outside our north and north-west coast, and that the two waves in their collision had tossed themselves to an abnormal height. The highest readings recorded are 31·108 in. at Ochtertyre, and 31·106 in. at Fort-William on the morning of the 9th ; and the former is therefore ·062 in. above the previous British maximum of 31·046 in. noted at Gordon Castle at 9 a.m. on January 8th, 1820.

Let us now proceed to the discussion of the charts drawn at the Meteorological Office. On the first, for January 6th at 8 a.m., the isobar

of 30·6 in. embraced the north of Germany and north-east of France, the Lowlands of Scotland, Ireland as far as the centre, and the whole of England, except the extreme end of Cornwall. No 8 a.m. temperature below 32° was reported, except towards Central Europe.

The second map for January 7th, 8 a.m., had 30·7 in. for its highest isobar. The whole system lay much to the westward of its position on the 6th, and enclosed Ireland, spreading apparently from the westward a tongue over North Wales and the Midland counties. The temperature was several degrees lower than on the previous day, but not below the freezing-point, and at the time the barometer was rising decidedly at our extreme western stations. The map for the morning of January 8th presents no

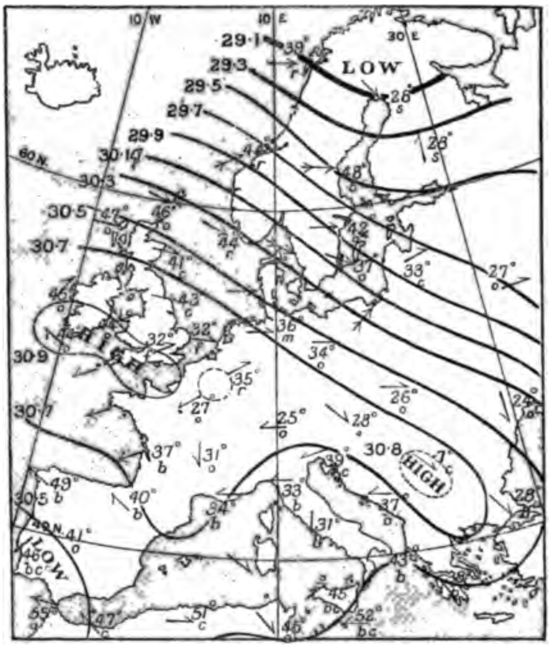


FIG. 2.—Weather Chart, 8 a.m., January 30th, 1896.

feature of great interest, but on the evening of that day the mercury rose at 6 p.m. to 31·01 in. at Stornoway, already mentioned, and to 31·00 in. at Wick, while our observer at Dunrossness in Shetland got a reading of 31·04 in. at midnight.

By next morning (January 9th), as we see from Fig. 1, the isobar of 31 in. embraced the whole of Scotland, the northern half of Ireland and the extreme north of England. Temperature was still above the freezing-point, except at Ardrossan, Stornoway, and some few of the inland Scotch stations. This was the day of highest readings, when 31·108 in. was reported from Ochtertyre at 9 a.m. The entire system then moved south-westwards, and the next chart for the morning of the 10th showed no reading of 31 in., though Belmullet, with 30·99 in., went very near that level. The curve for 30·9 in. enclosed Ireland, and at

the centre of the island (at Parsonstown) we had the thermometer down to 25°.

Pressure now gradually became reduced, and the anticyclone moved farther southwards. The later maps have not been reproduced for exhibition to the Society, but that for January 12th showed the highest isobar (four-tenths lower than that on the 10th) just covering the extreme southwest of Ireland.

It appears, therefore, that it is not quite correct to exclude the original European anticyclone from any action in producing the excessive high pressures which prevailed on the 8th and succeeding days.

The Tables I. II. and III. give the extreme readings which have come in from the stations in connection with the Meteorological Office and the Society.

At all the self-recording observatories but one the maximum reading of the first system was duly recorded. There is always this difficulty with photographic instruments, that you cannot see how they have acted until the photograph has been developed, and if the mercury has either

Anticyclone, January 9th–10th, 1896.

TABLE I.—Maximum Pressures at the Observatories in connection with the Meteorological Office.

Observatory.	Maximum Pressure.	Date and Time.	Number of hours above 31 in.
	in.		
Fort-William	31·106	9th, 10.12 a.m.	29
Glasgow	31·091	9th, 9.45 a.m.	19
Aberdeen*	31·061 (approx.)	9th, 10.0 a.m.	21
Stonyhurst	31·041	9th, Noon	14
Valencia	31·001	9th, 9.40 p.m.	...
Kew	30·930	9th, 9.10 p.m.	...
Falmouth	30·921	9th, 10.15 p.m.	...

* The assistant failed to lower the tube, thereby causing the loss of record.

TABLE II.—Barometrical Readings at the Telegraphic Reporting Stations at 8 a.m.

Station.	Jan. 9.	Jan. 10.	Station.	Jan. 9.	Jan. 10.
	in.	in.		in.	in.
Sumburgh Head	30·97	30·68	Parsonstown	30·99	30·98
Stornoway	31·06	30·87	Roche's Point	30·94	30·96
Wick	31·01	30·73	Pembroke	30·94	30·90
Nairn	31·04	30·86	Scilly	30·81	30·82
Leith	31·04	30·84	Prawle Point	30·83	30·83
Shields	31·00	30·83	Jersey	30·77	30·79
Spurn Head	30·91	30·78	Hurst Castle	30·80	30·83
Loughborough	30·93	30·85	Dungeness	30·76	30·76
Ardrossan	31·09	30·90	North Foreland	30·80	30·77
Malin Head	30·99	30·91	Oxford	30·92	30·86
Belmullet	31·03	30·99	Cambridge	30·90	30·83
Donaghadee	31·03	30·93	Yarmouth	30·84	30·77
Holyhead	30·99	30·89			

TABLE III.—HIGHEST OBSERVED PRESSURES ON JANUARY 9TH AT STATIONS OF THE SECOND ORDER.

Station.	Highest Reading.	Time.	Station.	Highest Reading.	Time.
	in.			in.	
Deerness (Orkney)	31·044	9 a.m.	Bidston Observatory	31·009	9 a.m.
Strathpeffer	31·076	10 a.m.	Llandudno	31·001	9 p.m.
Gordon Castle	31·058	9 a.m.	Colwyn Bay	31·002	10 a.m.
Kilmuir	31·084	9 a.m.	Buxton	30·986	9 p.m.
Inverness	31·088	9 a.m.	Stoke-on-Trent	30·993	9 p.m.
Fort Augustus	31·096	9 a.m.	Cheadle	30·996	9 p.m.
Rothven	31·084	9 a.m.	Churchstoke	31·008	9 p.m.
Dundee	31·052	9 a.m.	Uppingham	30·960	9 p.m.
Ochtertyre	31·108	9 a.m.	Belvoir Castle	30·957	9 p.m.
Stronvar	31·092	9 a.m.	Geldeston	30·915	9 p.m.
Dollar	31·098	9 a.m.	Stokesay	30·974	9 a.m.
Perth	31·071	9 a.m.	Rugby	30·905	8.30 a.m.
Duntreath	31·100	9 a.m.	Ross	30·965	10.25 a.m.
Edinburgh	31·072	9 a.m.	Cheltenham	30·975	9 p.m.
North Esk Reservoir	31·070	9 a.m.	St. David's	30·986	9 p.m.
Paisley	31·083	9 a.m.	Haverfordwest	30·984	9 p.m.
Rothesay	31·075	9 a.m.	Bennington	30·944	9 p.m.
Hawick	31·051	9 a.m.	Egham	30·908	3 p.m.
Benquhat	31·074	9 a.m.	Norwood	30·906	9 p.m.
Pinmore	31·087	9 a.m.	Chatham	30·868	9 a.m.
Morpeth	31·050	9 a.m.	Bramley	30·916	9 p.m.
Newcastle-on-Tyne	31·039	9 a.m.	Southampton	30·917	9 p.m.
Durham	31·007	9 a.m.	Eastbourne	30·863	9 p.m.
Gilcrux (Carlisle)	31·038	9 a.m.	Parkstone	30·928	9 p.m.
Aysgarth	31·015	9 a.m.	Rousdon	30·916	9 p.m.
Scarborough	30·976	9 p.m.	Tavistock	30·930	9 p.m.
Cronkbourne, I.M.	31·048	2 p.m.	Londonderry	31·075	9 a.m.
Heysham, Lancaster	30·977	9 a.m.	Armagh	31·057	9 a.m.
Skipton	30·955	9 a.m.	Markree Castle	31·030	9 a.m.
York	31·018	3-4 p.m.	Arley Cott., Mt. Nugent	31·053	9 a.m.
Blackpool	31·014	9 a.m.	Ardgillan	31·043	9 a.m.
Prestwich	30·989	9 a.m.	Glasnevin	31·030	9 p.m.
Manchester	30·997	9 a.m.	Dublin, Phœnix Park	31·029	9 p.m.
Owen's College	31·000	9 p.m.	Dublin	31·020	9.10 a.m.
St. Helen's	31·002	9 a.m.	Parsonstown	31·029	9 p.m.
			Killarney	31·001	9 p.m.

risen above or fallen below the field of illumination the absolute extreme is lost. Fortunately the station where this calamity occurred was not close to that where the highest level of the mercury was reached, and at Fort-William and Glasgow the actual maximum was recorded.

It may be interesting to offer a few remarks on the day of highest readings connected with the second intense anticyclone at the end of the month. From the map for 8 a.m., January 30th (Fig. 2), it will be seen that the isobar of 30·9 in. included the south of Ireland, the south-west of England, and a portion of the west of Normandy. The actual highest reading on this occasion was 30·96 in. at Roche's Point on the night of the 29th. Just as on the former occasion, the temperature at 8 a.m. was not low in these islands, and the map shows how very much smaller in area was the second anticyclone than the first. The extreme readings are given in Tables IV., V., and VI.

Anticyclone, January 29th–31st, 1896.

TABLE IV.—Maximum Pressures at the Observatories in connection with the Meteorological Office.

Observatory.	Maximum Pressure.	Date and Time.
	in.	
Fort-William	30·766	31st, 4.0 a.m.
Glasgow	30·773	30th, 9.45 p.m.
Aberdeen	30·698	31st, 11.12 a.m.
Stonyhurst	30·897	29th, 7.45 p.m.
Valencia	30·956	29th, Midnight.
Kew	30·936	30th, 10.0 a.m.
Falmouth	30·938	29th, 10.15 p.m.

TABLE V.—Barometrical Readings at the Telegraphic Reporting Stations at 8 A.M.

Station.	Jan. 30.	Station.	Jan. 30.
	in.		in.
Sumburgh Head	30·31	Holyhead	30·86
Stornoway	30·58	Parsonstown	30·91
Wick	30·51	Valencia	30·91
Nairn	30·56	Roche's Point	30·94
Aberdeen	30·63	Pembroke	30·92
Leith	30·70	Scilly	30·86
Shields	30·72	Prawle Point	30·90
Spurn Head	30·78	Jersey	30·90
Loughborough	30·83	Hurst Castle	30·91
Ardrossan	30·77	Dungeness	30·88
Malin Head	30·78	North Foreland	30·88
Belmullet	30·87	London	30·90
Donaghadee	30·84	Oxford	30·91
Bidston Observatory	30·87	Cambridge	30·87
		Yarmouth	30·81

It may be of interest to add to these notes, as a supplement to Mr. Wallis's paper, of 14 years back, a notice of the excessive readings which have occurred in Siberia of late years. In vol. x. of the *Meteorologische Zeitschrift*, in the part for March 1893, there is a note by our Honorary Member, Dr. Woeikof, on this subject. Herr Sresnewski had stated that on January 14th, 1893, a reading had been recorded at Irkutsk, which, when duly reduced, came to 807·2 mm. or 31·78 in. Dr. Woeikof disputes this statement, *inter alia*, because the temperature for reducing *up* to the freezing-point had been taken at $-51^{\circ}\cdot34$ F., and had been assumed to prevail from Irkutsk to the sea. He maintains that the reading of 803 mm.; or 31·62 in., at Barnaoul, December 14th, 1877, is really the best established barometrical maximum as yet on record.

These readings, however, have been so much corrected, especially as to the reduction to sea-level for stations some thousands of miles from the nearest sea, that they are not so easily intelligible as our own readings taken, so to speak, on the seashore. We can, however, feel pretty confident that as yet no reading of 32 in. has been registered.

I must say in conclusion that I am indebted to Mr. Gaster for in-

TABLE VI.—HIGHEST OBSERVED PRESSURES ON JANUARY 29TH–31ST AT STATIONS OF THE SECOND ORDER.

STATION.	Highest Reading.	Time.	STATION.	Highest Reading.	Time.
	in.			in.	
Deerness .	30·566	30th, 9 p.m. / 31st, 9 a.m.	Rugby . .	30·968	30th, 8.30 a.m.
			Cheltenham .	30·915	29th, 9 p.m.
Strathpeffer .	30·675	31st, 9 a.m.	St. David's .	30·943	29th, 9 p.m.
Edinburgh .	30·758	30th, 9 p.m.	Haverfordwest .	30·953	29th, 9 p.m.
Hawick . .	30·778	29th, 9 p.m.	Bennington .	30·920	29th, 9 p.m.
Newcastle-on-Tyne . .	30·818	29th, 9 p.m.	St. Albans .	30·925	30th, 9 p.m.
			Egham . .	30·928	30th, 9 a.m.
Durham .	30·786	29th, 9 p.m.	Norwood . .	30·906	29th, 9 p.m.
Gilcrux . .	30·842	29th, 9 p.m.	Chatham . .	30·922	30th, 9 a.m.
Aysgarth .	30·810	29th, 9 p.m.	Bramley . .	30·917	30th, 9 a.m.
Scarborough .	30·823	29th, 9 p.m.	Southampton .	30·922	30th, 9 a.m.
Cronkbourne, I.M. . .	30·879	29th, 9 p.m.	Eastbourne .	30·902	30th, 9 a.m.
			Parkstone . .	30·938	30th, 9 a.m.
Heysham .	30·838	29th, 9 p.m.	Rousdon . .	30·916	30th, 9 a.m.
York . .	30·835	29th, 9 p.m.	Tavistock . .	30·940	29th, 11 p.m.
Stonyhurst .	30·886	29th, 9 p.m.	Londonderry .	30·854	29th, 9 p.m.
Prestwich .	30·865	29th, 9 p.m.	Armagh . .	30·883	29th, 9 p.m.
St. Helen's .	30·863	30th, 9 a.m.	Markree Castle .	30·875	29th, 9 p.m.
Bidston Obs. .	30·901	29th, 9 p.m.	Arley Cottage, Mt. Nugent .	30·903	29th, 9 p.m.
Llandudno .	30·891	29th, 9 p.m.			
Buxton . .	30·873	29th, 9 p.m.	Glasnevin . .	30·925	29th, 9 p.m.
Cheadle .	30·893	29th, 9 p.m.	Dublin, Phœnix Park	30·919	29th, 9 p.m.
Churchstoke .	30·941	29th, 9 p.m.			
Uppingham .	30·888	29th, 9 p.m.	Dublin . .	30·913	29th, 9 p.m.
Belvoir Castle	30·879	29th, 9 p.m.	Parsonstown .	30·914	29th, 9 p.m.
Geldeston .	30·870	29th, 9 p.m.	Killarney . .	30·953	29th, 9 p.m.
Stokesay .	30·913	29th, 10.30 p.m.			

valuable assistance in preparing the paper. It is to him that I owe all the slides which have been exhibited at the meeting.

DISCUSSION.

THE PRESIDENT (MR. E. MAWLEY) expressed the thanks of the Society to Mr. Scott for his promptness in bringing forward this paper. It was seldom that so complete a record of any meteorological phenomenon of unusual interest was presented to the Fellows less than six weeks after its occurrence.

Mr. R. INWARDS thought that one defect in our self-registering barometers had been brought out by this paper, and that, at any rate, the principal stations should have instruments reading up to 32 in.

Mr. G. J. SYMONS said that given a competent observer, he much preferred the standard barometer to any recording instrument. He had curves from several patterns of barograph, and in several cases eye observations taken at the same place or in the neighbourhood, and, in his opinion, the latter were the more reliable. Of course if the standard barometer is not read at very short intervals, the recorder will give preferable results.

Mr. F. J. BRODIE called attention to the extremely mild weather prevalent during the periods under discussion. He had always associated winter anticyclones with frost and fog, but in the two discussed by Mr. Scott neither of these conditions prevailed to any degree, and from inquiries he had recently

made he was convinced that to the general rule there were many important exceptions. During the past 25 winters there were 7 cases in which the mean pressure at Kew was considerably above the average, and in which the weather charts showed the existence of a strong anticyclonic tendency. In no fewer than 5 out of the 7 the mean temperature was above the normal, the numbers of days both of frost and fog being comparatively small. Taking again the cases in which the barometer in London reached an unusually high level (30·8 in. or more), he found that in each of the 6 instances which had occurred during the past 25 years (including those mentioned in the present paper) there was an absence of anything like severe frost, while in one of the cases (viz. in February 1883) the weather was very mild. The weather experienced during the prevalence of an anticyclone depended of course to a large extent upon the position of the central portion of the system, for if this lay to the eastward or southward of us, the prevailing winds would be Southerly or Westerly, and the weather naturally somewhat mild. The general character of a season is, however, not determined solely by the prevailing distribution of pressure. Every now and again there is a distinct tendency for the weather to be cold or warm, or dry or wet; and when this tendency exists, as it has during the present winter, the effect of the barometrical changes is to a large extent masked. Until the nature and origin of these mysterious tendencies are better understood, it is hopeless to expect much advance in the direction of weather forecasts for any long time ahead.

Mr. C. Harding remarked that the anticyclone of January 1882 was also accompanied by extremely mild weather. Concerning Mr. Brodie's remark on the situation of the centre of the high pressure system, he (Mr. Harding) thought that in the present case it would have made but little difference to the temperature, as no part of the system was marked by low temperatures. At the Azores, where the range of the barometer was generally small, the mean pressure for January was 30·13 in., being in agreement with the average for several years. In the earlier part of the month the barometer stood on one day at 29·04 in., a very low reading for the Azores, and on several days readings were exceptionally low, while the barometer in our islands was rapidly rising. He supposed it was generally accepted that the mean of the barometer at the earth's surface for all the world was always the same, so that when anticyclonic conditions prevailed here, it was at the expense of other districts under cyclonic influence. The anticyclonic systems discussed in the paper had travelled from the eastward, and had apparently been partially fed with air from cyclones lying over the Atlantic. The mean pressure for January in London was 30·35 in. as against an average of 29·98 in.

Mr. H. N. Dickson suggested that the anticyclonic system described in Mr. Scott's paper might be the result of the action of depressions surrounding it, inasmuch as the great descending currents over the Continent were probably weaker and more restricted than usual, while the ascending currents were not correspondingly diminished. With regard to the tendencies observed to persist through different types of weather, he expressed the opinion that these were in part due to variations in the distribution of surface water in the North Sea and North Atlantic. The recent international surveys of those areas had brought to light distinct indications of a connection between the two.

Mr. R. H. Scott, in reply, said that Dove, in his *Monats- und Jahresisothermen in der Polarprojection*, 1864, had shown that whenever abnormal cold was experienced, abnormal warmth was not very far off. A letter had recently appeared in the *Times* regarding the unhealthy conditions prevailing in St. Petersburg in the present winter owing to the rapid changes of temperature, which varied from 40° to 50° per day. The anticyclonic conditions usually prevailing in Russia at this time of the year were absent.

TURNER'S REPRESENTATIONS OF LIGHTNING.

By RICHARD INWARDS, F.R.Met.Soc., F.R.A.S.

[Read February 19, 1896.]

The truth to nature of Turner's representations of lightning flashes has been several times mentioned before the Society, but I thought it would be interesting to bring before the Fellows an actual example of Turner's work, placed side by side with a photograph of a real flash of lightning, presenting the same general character—and perhaps coming under the head of meandering lightning; at all events, it is a flash of that kind which seems to attempt to double back upon itself, and which makes many sudden turns before getting finally on its earthward course.

Turner's Lightning.

Photograph of Lightning.

In the accompanying figure is a copy of part of Turner's picture of the Bass Rock, which is an island in the Firth of Forth, Scotland.

Collated with this view is a photograph from the Society's collection, and which was, of course, taken direct from nature. It will be seen that Turner has caught the general form and character of the rapid contortions and abrupt curves of the lightning with a most amazing fidelity, and he has even drawn the flash in several places by a doubled line, just as we often see in photographs from nature. In fact there is a doubled part in the photograph.

If the picture had been by any one but Turner I should have put this down to a mere careless stroke of the brush, but being from the hand of so consummate a master, I can have no doubt that his keen eye saw the effect, which his swift hand almost as quickly committed to paper. This doubling of the flash is thought by some meteorologists to indicate an exchanging discharge between the different electricities of the cloud and of the earth in two opposite but almost parallel directions. These features are not well seen in the small illustrations, but are plainly visible in the originals.

It must not be supposed that the example I have shown you is the only instance of the great English master's power in this direction. There

is a plain flash of "stream lightning" in the picture of the Temple of Minerva at Cape Colonna, and there is a good example of the tree-like or branch-like form of flash in a picture of the "Devil's Bridge" which is to be seen amongst the Turner sketches in the basement of our National Gallery.

Neither of these examples would suffer by being confronted with photographs taken direct from nature, in the same way as I have treated the Bass Rock picture.

With respect to this doubling of the flash, so often seen in photographs, it is interesting to note a passage in Mr. Walter Kelly's *Indo-European Folk-Lore*, 1863, p. 24, where, speaking of the thunderbolt which was the weapon of Indra, he says, "We will only mention that every time it was hurled by the god it returned of itself to his hand. So also did Odin's spear, and the same extremely convenient property was manifested on all ordinary occasions by Thor's lightning club or hammer. . . . In consequence of this peculiarity of the hammer or thunderbolt it was necessary to take precautions not only against its direct blow, but also against its back stroke when it was returning to its master's hand. For this reason it continues to be the custom in many places in Bavaria, as Mannhardt relates, to throw open all the windows as wide as possible during a thunderstorm, so that if the lightning enter the house it may have free vent to get out again."

This custom is also followed in some parts of England, and it is very curious to find the belief in a double flash extending from India to Scandinavia. Perhaps our keener sighted forefathers, like Turner, saw the doubling of the lightning.

I have been privileged to see the valuable collection of Turner's proofs and plates from the *Liber Studiorum* in the possession of Mr. W. G. Rawlinson, of Hill Lodge, and it may be interesting to name the following among Turner's representations of lightning:—

No. 15. *Lake of Thun.*—This not only shows the lightning flash, but immediately under where it issues from the cloud there is a kind of conical and somewhat spiral mass of light rising from the lake, which, Mr. Rawlinson says, compares with what he himself once saw over the head of Loch Awe during a thunderstorm.

No. 16. *The fifth plague of Egypt.*—Shows a stream of lightning issuing from the sky.

No. 52. *Solway Moss.*—Shows very similar lightning to that in the picture of the Temple of Minerva, and there is a flash of the same general character shown in the rare print of "Paestum."

No. 61. *The tenth plague of Egypt.*—I quote from Mr. Rawlinson's descriptive catalogue of the *Liber Studiorum* 1878, the references to the lightning as shown in the various states of this fine plate:—

First Published State.—"At the last angle made by the lightning before it strikes the buildings in the centre it divides, branching to the left towards the trees as well as to the right towards the buildings.

Second State.—"The lightning at the angle described above strikes to the right only, towards the buildings, the small fork to the left having been removed—the sky duller and the lightning less brilliant.

Third State.—"Much of the depth of the shadows lost, the buildings no longer stand out in relief by the lightning, the whole effect much duller."

In No. 82, *The Felucca*, one of the unpublished plates, and in another known as *Catania*, as well as in that representing *Dymchurch*, various forms of lightning are also shown; while in the *England and Wales* series there is a flash shown as avoiding the tower of Malvern Abbey and striking a low building near, with other examples in *Stamford*, *Stonehenge*, etc.

Any of these representations might be placed side by side with photographs of lightning, and would be found to convey faithfully to the mind all that the highest powers of sight can discover in the phenomena.

One is inclined to take literally the eulogium passed by John Ruskin on this great master: "Unfathomable in knowledge, solitary in power . . . sent as a prophet to reveal to men the mysteries of the universe."

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

January 15, 1896.

Ordinary Meeting.

Richard Inwards, F.R.A.S., President, in the Chair.

Mr. Symons referred to the death of Mr. E. J. Horstman, the senior assistant, which occurred on the 15th inst. Mr. Horstman had been in the employment of the Society for eighteen years, and was always a faithful and conscientious servant.

John Edmund Chandler, F.R.G.S., Frenches Park, Crawley Down, Sussex;
Richard John Cuninghame, Lainshaw, Stewarton, Ayrshire; and
Henry John Randall, Jun., Bridgend, Glamorganshire,
were balloted for and duly elected Fellows of the Society.

January 15, 1896.

Annual General Meeting.

Richard Inwards, F.R.A.S., President, in the Chair.

Mr. F. Druce and Mr. J. G. Wood were appointed Scrutineers of the Ballot for Officers and Council.

Mr. F. C. Bayard read the Report of the Council and the Balance-Sheet for 1895 (p. 99).

It was proposed by the President, seconded by Mr. F. C. Bayard, and resolved:—"That the Report of the Council be received and adopted, and printed in the *Quarterly Journal*."

It was proposed by Mr. M. Jackson, seconded by Major L. Flower, and resolved:—"That the thanks of the Society be given to the Officers and other Members of the Council for their services during the past year."

It was proposed by Dr. R. Barnes, seconded by Dr. H. R. Mill, and resolved:—"That the thanks of the Society be given to the Standing Com-

mittees and to the Auditors, and that the Committees be requested to continue their duties till the next Council Meeting."

It was proposed by Mr. W. H. DINES, seconded by Mr. R. H. SCOTT, and resolved:—"That the thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers, and also of the Surveyors' Institution, for having granted the Society free permission to hold its Meetings in the rooms of their respective Institutions."

The PRESIDENT then delivered an Address on "Meteorological Observatories" (p. 81).

It was proposed by Mr. G. J. SYMONS, seconded by Mr. R. H. CURTIS, and resolved:—"That the thanks of the Society be given to Mr. RICHARD INWARDS for his services as President during the past year, and for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal*."

The Scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year:—

PRESIDENT.

EDWARD MAWLEY, F.R.H.S.

VICE-PRESIDENTS.

ROBERT WILLIAM PEREGRINE BIRCH, M.Inst.C.E., F.G.S.
WILLIAM ELLIS, F.R.S., F.R.A.S.
RICHARD INWARDS, F.R.A.S.
Capt. DAVID WILSON-BARKER, F.R.S.E., F.R.G.S.

TREASURER.

HENRY PERIGAL, F.R.A.S., F.R.M.S.

SECRETARIES.

FRANCIS CAMPBELL BAYARD, LL.M.
GEORGE JAMES SYMONS, F.R.S.

FOREIGN SECRETARY.

ROBERT HENRY SCOTT, M.A., F.R.S.

COUNCIL.

ROBERT BARNES, M.D., F.R.C.P.
ARTHUR BREWIN.
GEORGE CHATTERTON, M.A., M.Inst.C.E.
RICHARD HENRY CURTIS.
HENRY NEWTON DICKSON, F.R.S.E.
WILLIAM HENRY DINES, B.A.
CHARLES HARDING.
Rear-Admiral JOHN PEARSE MACLEAR, R.N., F.R.G.S.
HUGH ROBERT MILL, D.Sc., F.R.S.E., F.R.G.S.
HENRY SOUTHALL, F.R.H.S.
HERBERT SOWERBY WALLIS.
CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

Mr. R. INWARDS having left the Chair, it was taken by Mr. E. MAWLEY, the newly elected President, who thanked the Fellows for the honour they had conferred upon him in electing him to that office.

February 19, 1896.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

Rev. WILLIAM CREE, Vicarage, Manningtree;

ALEXANDER JOHN CURRIE, M.D., F.R.G.S., 219 Onslow Drive, Dennistoun, Glasgow;

SAMUEL HARDMAN, F.R.G.S., 225 Lord Street, Southport; and

FREDERICK SMALLMAN, F.R.G.S., Hayesleigh, Stretford, Manchester, were balloted for and duly elected Fellows of the Society.

The following communications were read:—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1895." By EDWARD MAWLEY, F.R.H.S., President (p. 124).

"NOTES ON THE UNUSUALLY HIGH BAROMETER READINGS IN THE BRITISH ISLES IN JANUARY 1896." By ROBERT H. SCOTT, M.A., F.R.S. (p. 152).

"TURNER'S REPRESENTATIONS OF LIGHTNING." By RICHARD INWARDS, F.R.A.S. (p. 160).

CORRESPONDENCE AND NOTES.

Thunderstorms in Jamaica.—Throughout the West Indies thunderstorms occur daily during the wet season; the following remarks apply more particularly to Jamaica.

The late Prof. J. C. Houzeau lived in Jamaica between the years 1869-73; his residence was about six miles north-east of Kingston, at the foot of the St. Andrew's mountains, and he made certain meteorological observations which were published in Brussels, from which the following table is taken:—

Total Number of Days of Thunder for 5 years.

January	4	May	28	September	59
February	3	June	31	October	23
March	2	July	42	November	9
April	2	August	50	December	16

Total for 5 years 269.

Now, all along the central line of hills in Jamaica heavy rains, accompanied by thunderstorms, occur every afternoon from the beginning of May to the end of October; and at the Kempshot Observatory, where I have lived more or less continuously for twenty years, thunderstorms occur so frequently that, unless some recognised system of recording their number be established, there is but little use in making notes. Three or four thunderstorms may often be seen and heard in progress at the same time; two or three thunderstorms often pass over the place of observation during the same day; and sometimes a number of small storms join together, intensify and sweep the island from its middle westwards, the rain-curtain being at least 30 miles in length, and the lightning being incessant along the line of advance.

Consequently the numbers in the table above given must be accepted with the greatest caution; for instance, it is perfectly true that a little distant thunder

may often be heard in December, and I have no doubt that such thunder has been heard on 16 days during the 5 years in question; but the numbers 16 and 59 applying to December and September are wholly misleading as to the frequency and intensity of thunderstorms during those months; 16 and 5000 would be much nearer the mark in the west-central parts of Jamaica!

Thunderstorms rarely occur in Jamaica except when rain is falling, or is about to fall, from large *cumuli;* and the lightning is almost invariably straight down to the ground. As a rule the heavier the rain, where time and quantity are both considered, the greater the thunderstorm; but there are marked exceptions to this rule; so that the quantity of electricity in the cloud has to be taken into consideration as well. Lightning consequently easily "makes earth" in Jamaica by means of wet trees; and it is only during the month of September, when thunderstorms are at their maximum, that any anxiety need be felt. For the protection of buildings I have recommended an arrangement which has answered well for many years at Kempshot: a copper rod three-fifths of an inch thick is attached to a pole (or flag-staff), which is much higher than the surrounding buildings; the rod terminates in a few copper spikes, and is well connected with a large copper earth-plate. This lightning conductor is not connected with the buildings. The buildings have all metallic gutters connected together, and with the earth, by means of a small rod attached to the kitchen chimney, this second rod also having spikes above and an earth-plate below. And then by means of the two earth-plates and some very simple galvanic apparatus, it becomes easy to test the conducting power of the rods and plates from year to year. The taller rod is often struck, when it makes a sound like a dull crack of a whip, and then thunder is heard in about two seconds from overhead. It often happens that the rod is thus struck twice in five minutes.

Hail does not often fall in Jamaica; tornadoes are almost unknown; and waterspouts are seldom seen at sea. But although hail does not often reach the ground, it can sometimes be heard falling at a great height in the air; the sound is like that of the rushing of a railway train at the distance of a mile or so; and the rain which reaches the ground is cold at Kempshot, 1773 feet above sea-level, and cool at the sea-level, the temperatures being about 65° and 75° respectively.

Now, as far as altitude is concerned, the temperature decreases under normal circumstances in Jamaica at the rate of 1° for every 315 feet; but when rain is falling from a thunder-cloud the rate is 1° for every 177 feet according to the circumstances stated above.

The barometer rises about 0·03 in. in a quarter of an hour before the passage of the centre of the storm, and falls to the same extent in half an hour after the passage of the centre.

As the *cumulus* and *nimbus* approach, the sound of the rain on the leaves of the forests may be heard at a distance of two or three miles, then the surface wind begins to blow towards the storm, and no doubt upwards at the same time; then there is a calm; then cool wind blows from the storm; and finally the wind and rain come together in squalls. This rain-wind is merely due to the passage of the *cumulus* and *nimbus* taken as a whole; that is to say, if the *cumulus* rain and all be drifting through the atmosphere at the rate of 20 or 30 miles an hour, this will be the velocity of the rain-wind at the surface.

In the case of large *cumuli* which discharge rain and lightning we have therefore mechanism different to that which produces tornadoes and cyclones. It may be asked if I have never observed rotatory motion round the axes of the *cumuli*, and my reply is, only on one or two occasions when, if the action had been continued, some minor form of whirlwind would have been experienced.

For the origin of cyclones we must undoubtedly look to large areas of low pressures round which the winds may begin to sweep, urged by the differential effect of the earth's rotation upon moving currents of air. MAXWELL HALL.

Evaporation at Kimberley, South Africa.—The evaporation gauge at Kimberley is a wrought-iron tank 4-feet cube, sunk into the ground within about an inch of the top and kept nearly full of water. There is a rain gauge close at hand. The levels of the water in the tank are taken daily by means of a hook gauge specially designed by Mr. R. H. Twigg, the engineer to the Kimberley Waterworks Co., who own the evaporation gauge. The hook gauge consists of a heavy hook having a very sharp point. It is suspended by means of a metallic cord passing over a pulley; this cord is attached to one end of a horizontal vernier scale, which can be moved by a screw with micrometer head, enabling the observations to be made to ·001 inch. The suspension of the hook by a cord is found advantageous in preventing the vibrations, arising from operating the screw, disturbing the water surface, and the horizontal scale is more convenient to read than if it were vertical. R. H. TWIGG.

Evaporation at Kimberley.

Month.	1891.	1892.	1893.	1894.	1895.	Mean.
	in.	in.	in.	in.	in.	in.
January . . .	10·30	11·94	10·34	10·17	12·38	11·1
February . . .	8·59	11·30	10·00	5·41	8·66	8·8
March . . .	6·30	7·50	9·14	7·20	8·44	7·7
April . . .	5·08	6·43	7·79	6·56	5·06	6·2
May . . .	5·05	5·97	6·98	4·73	5·13	5·6
June . . .	3·68	4·00	5·10	4·31	4·42	4·3
July . . .	4·11	5·19	4·68	5·13	4·89	4·8
August . . .	5·30	6·84	6·16	6·44	7·57	6·4
September . . .	8·27	8·34	8·09	8·04	8·73	8·3
October . . .	10·46	8·86	11·00	10·83	12·93	10·8
November . . .	9·08	12·18	10·57	11·48	11·84	11·0
December . . .	10·46	15·84	11·47	10·96	11·79	12·1
Total . . .	86·68	104·39	101·32	91·26	101·84	97·1

Rainfall at Kimberley.

Month.	1891.	1892.	1893.	1894.	1895.	Mean.
	in.	in.	in.	in.	in.	in.
January . . .	3·10	·79	4·44	6·38	1·30	3·20
February . . .	3·93	·89	1·81	4·85	2·26	2·75
March . . .	4·96	5·14	1·56	2·57	1·93	3·23
April . . .	3·55	·76	1·23	·95	3·13	1·92
May . . .	·28	·07	...	·83	1·07	·45
June . . .	1·06	·95	·80	·06	...	·57
July . . .	·11	·05	·07	...	·20	·09
August . . .	1·01	·10	·64	·25	...	·40
September . . .	·43	1·69	...	·52	...	·53
October . . .	1·57	1·27	·23	·77	·10	·75
November . . .	5·24	·71	2·45	1·76	1·53	2·34
December . . .	5·84	·31	1·53	2·59	2·29	2·51
Total . . .	31·08	12·73	14·76	21·53	13·81	18·74

Movements of the Surface Waters of the North Sea.—Mr. H. N. Dickson has summarised the results of surveys made in the North Sea in 1893 and 1894 by Danish and Swedish ships, and also by ships from the Kiel Commission and the Fishery Board for Scotland. He finds that the distribution of water of all salinities over the surface of the North Sea varies within very wide limits, both as to size and position of the areas covered, and it may be altogether

different at the same season in different years, and practically the same at quite different seasons in the same year. Hence it appears that the forces which produce the changes act rapidly; a change of distribution at the surface may be wholly or chiefly due to forces which have come into action only a short time before. The chief influence at work locally is the wind, which has also a profound effect on the surface supplies of oceanic water. The observations show that:—

1. Calm weather favours the spread of a thin layer of water of 34 per mille salinity over a great part of the surface of the North Sea, the result of previous mixing.

2. Strong Northerly (N.E., N., or N.W.) winds tend to broaden the area covered by 35 per mille (oceanic) water, and to blunt its extremity, and the surface salinity on the whole is increased, the fresher outflowing waters being driven back. One very important effect is to send water between 33 and 34 per mille southwards along the west coast of Norway; and further investigation may show that these conditions are responsible for the influx of "bank water" into the Skagerak, which has been found to coincide with the period of the Swedish herring fishing.

3. Westerly and South-westerly winds tend to form a continuous strip of 35 per mille water along the whole of the central axis of the North Sea, probably because the oceanic streams are strengthened, but at the same time mixing goes on rapidly, and there is a strong upwelling from the British coasts.

4. Easterly and South-easterly winds reduce the salinity as a whole by spreading the fresher waters over the surface. The oceanic water is covered over, or shows a small area close to the coast of Scotland.

Cloud Atlas.—The editors have received the prospectus of the forthcoming *Cloud Atlas*, and they think it may be acceptable to the Fellows to give a translation of it.

Circular from the Cloud Committee.

The Meteorological Conference of Munich, in 1891, recommended, by a majority, the system of cloud classification, proposed by Messrs. Hildebrandsson and Abercromby, and nominated a Committee for the purpose of publishing a Cloud Atlas containing coloured reproductions of the principal types of clouds, and of the secondary forms which are also seen in addition to the simple forms.

After preparatory correspondence, etc., the Committee met at Upsala in 1894, at the same time as the International Meteorological Committee assembled there. They organised an exhibition of more than 300 specimens of representations of clouds from almost all parts of the world, and from this they selected the examples for the Cloud Atlas. At the same time the Committee decided on the definitions of the different forms, and prepared instructions for cloud observations. The minutes of the proceedings of the Committee were submitted to the International Committee, and were, with some slight modifications, adopted. Finally the undersigned were named as a Sub-Committee for Publication.

It is needless to enumerate all the difficulties which were met in the production of the Atlas at a moderate price. After several attempts we are able to submit to meteorologists this official Atlas in a form as elegant and complete as could be obtained without too great an increase of cost. The plates have been submitted and approved by a number of eminent meteorologists, and the text, in three languages, contains the definitions and instructions adopted at Upsala. We hope, therefore, that the Atlas will be very useful to all engaged in the study of clouds, observations which become daily more and more important to the science of meteorology, whether from the point of view of theory or of that of

weather prediction. The Atlas is on sale by MM. Gauthier Villars et fils, 55 Quai des Grands Augustins, Paris. Price 9 francs; for 10 copies 80 francs.
H. H. HILDEBRANDSSON, A. RIGGENBACH, L. TEISSERENC DE BORT. *Upsala, Basle, Paris, April* 1896.

The Atlas consists of 14 plates containing 30 separate figures.

Climate of Venezuela.—Few meteorological records have been kept in Venezuela, and therefore the climate can be described only in general outlines. As in other countries of South and Central America, three zones are recognised —the *Tierra caliente*, extending from sea-level up a height of about 1800 feet; the *Tierra templada*, reaching up to about 7200 feet; and, above this, the *Tierra fria*. These zones have mean annual temperatures of 86° to 77°, 77° to 60°, and below 60° respectively. On the north coast the heat is excessive, owing to the Trade-wind which blows across the hot Caribbean Sea. Maracaibo is said to be the hottest place on the coast, though La Guayra, situated on an exposed mountain flank and unsheltered by forest, is known as El Infierno de Venezuela; the mean yearly temperature is 85° and the minimum over 77°. But what makes the heat more felt here is the small difference between day and night temperatures, amounting, even in the cooler months, to only 5° or 6°. Caracas, lying at an elevation of 3000 feet above sea-level, and therefore in the *Tierra templada*, enjoys a cooler and more agreeable climate. Its mean annual temperature is 71°. In the hottest months the thermometer ranges from 68° to 82°, and in the coolest from 71° to 52°.

In the Cordillera the changes of temperature are naturally very great, as the traveller may in a few hours ascend from the sheltered valleys to the bleak, wind-swept *paramos*, the high plains above the forest limit. It may be assumed that in general the temperature in the Cordillera diminishes at the rate of 1° for every 365 feet. But local conditions vary the changes, which are greater in the midst of the mountains than on their outer slopes. In the lower parts, though the heat is very great, it is not so extreme as in many other tropical countries, and is not so high on the northern slope as on the southern, in the Llanos, and in Central Venezuela, for on the north humidity moderates the temperature and the luxuriant vegetation wards off the burning rays of the sun. The highest readings of the thermometer have been observed in the Llanos: in Acarigua, south of the Portuguesa range, Dr. Sievers observed a temperature of 125½° in the sun and 89½° in the shade, in October 1885, at 2 p.m., while Sachs at Calabozo found the mean of the readings at the same hour during February 1877 to be 96°. As a rule the bare and dry tracts are warmer than the woodlands.

The rainfall is given by the Graf zu Erbach in *Wandertage eines Deutschen Touristen im Strom- und Küstengebiet des Orinoko*, after Villavicencio, as 70 in. at Maracaibo, 68½ in. at the lake of Valencia, 65 in. on the Caribbean coast, 63 in. on the Gulf of Paria, about 60 in. along the Orinoco, and 31½ in. at Caracas. In the Tachira valley and in Western Merida there is a lesser rainy season in spring, and a greater rainy season beginning at the end of July, while a short dry period intervenes, called the "little summer of St. John." When the sun is near the Tropic of Cancer, but in the highlands farther east, lying also in a more northern latitude, the short, dry period disappears and the rainy seasons merge into one.—*Scottish Geographical Magazine*, April 1896.

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY

VOL. XXII.] JULY 1896 [No. 99.

MEAN AMOUNT OF CLOUD ON EACH DAY OF THE YEAR, AT THE ROYAL OBSERVATORY, GREENWICH, ON THE AVERAGE OF THE FIFTY YEARS 1841 TO 1890.

By WILLIAM ELLIS, F.R.S.

[Read April 15, 1896.]

IN my address to the Royal Meteorological Society in the year 1888 I included a discussion of the observations of cloud made at Greenwich, principally at the Royal Observatory, during the seventy years ending 1887. The inquiry was confined to a consideration of monthly values, and I have long desired to supplement it by an endeavour to establish, from daily values, the form of the mean annual curve more completely than mean monthly values will permit. Tables of monthly values of the various meteorological elements are numerous, but determinations of the daily march of any element through the year, as found by combining together the results for a number of years, are not so frequently made. And yet the interest attaching to such more complete exhibition of the annual curve is correspondingly greater. But the labour involved in calculating mean daily values from the observations of a long series of years is considerable, and may often prevent such work being undertaken.

The paper now presented to the Society includes a table of the mean daily values of cloud, for each day of the year, as deduced from the observations of the fifty years 1841 to 1890. No separate daily values having been formed during the earlier portion of the seventy years previously employed, I have contented myself with using, in this newer work, the results of the observations made at Greenwich since the establishment of the Magnetical and Meteorological Observatory in the year 1841, since which time separate daily values are available. This is, on the whole, probably an advantage, since the period now employed is the same as that used in the formation of the tables of mean temperature and mean maximum and mean minimum temperature of the air, for each

day of the year, as given in papers contained in the *Quarterly Journal* of the Society, vol. xviii. p. 237, and vol. xix. p. 211. The adoption, when possible, of the same period in tabulations of similar nature is useful as facilitating inter-comparison of results.

TABLE I.—Mean Amount of Cloud on each Day of the Year, at the Roya Observatory, Greenwich, as found from the Observations of the Fifty Years, 1841 to 1890.

Day	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	7·3	7·1	7·7	6·4	6·2	5·6	6·9	6·5	5·8	6·3	7·2	7·0
2	7·3	7·8	7·3	6·3	5·8	6·3	6·9	6·8	6·6	6·6	7·1	7·0
3	7·7	7·6	6·8	6·3	6·3	6·5	7·4	7·0	6·2	6·1	6·4	7·7
4	7·0	7·5	6·7	6·2	6·3	6·0	6·5	6·4	6·3	6·9	7·1	7·3
5	7·2	7·9	6·8	6·8	6·1	6·8	5·9	6·1	6·0	6·4	7·2	6·9
6	7·3	7·2	6·5	6·6	6·4	7·2	6·6	6·8	6·2	6·8	6·8	7·3
7	6·6	7·9	7·3	6·6	6·7	7·5	6·9	6·4	6·0	6·9	7·2	7·5
8	7·6	7·3	7·3	6·5	6·9	6·9	6·9	6·6	7·0	6·8	6·8	7·3
9	7·2	7·3	6·7	7·0	6·9	6·9	7·0	6·7	6·5	7·2	6·7	7·8
10	7·9	7·0	6·9	6·8	7·2	6·7	6·3	6·7	6·4	6·7	7·1	7·3
11	7·8	7·5	6·9	6·9	6·8	6·3	7·0	6·7	6·0	6·4	7·1	7·1
12	7·5	6·9	7·3	6·8	6·5	7·0	6·3	6·1	5·9	6·4	6·4	7·3
13	8·3	7·3	6·4	7·2	6·2	6·3	6·5	6·7	5·7	7·2	7·5	7·6
14	7·7	8·0	7·4	7·2	6·9	5·9	6·0	6·5	6·4	6·4	7·3	7·2
15	7·3	7·5	7·1	7·1	6·3	6·3	6·0	6·6	6·1	6·9	7·4	8·0
16	7·8	7·2	6·8	6·5	6·5	6·6	6·6	6·5	6·5	6·7	7·2	8·1
17	8·0	7·0	6·6	6·5	6·5	6·9	7·0	6·7	6·3	6·5	6·8	7·8
18	8·0	7·1	6·3	6·2	6·5	7·1	6·5	6·9	5·9	6·8	6·7	7·1
19	7·9	7·6	7·4	6·1	6·9	7·2	7·1	7·0	6·1	7·1	6·9	6·6
20	7·7	7·0	7·6	5·8	6·2	7·2	6·8	6·7	5·8	6·5	6·7	7·5
21	7·8	7·4	7·3	5·8	6·5	6·7	6·0	6·4	6·5	7·3	7·4	8·0
22	7·7	7·7	7·3	6·7	6·3	6·4	6·5	6·2	6·0	7·0	7·8	7·8
23	7·2	7·3	6·7	6·2	6·1	6·2	6·8	6·3	6·9	7·4	7·0	7·3
24	7·5	7·4	6·4	6·8	6·3	6·6	6·8	5·8	6·9	7·2	7·3	7·0
25	6·9	7·8	6·7	6·6	6·3	6·7	6·8	6·6	5·6	7·2	7·3	6·8
26	6·5	7·4	6·9	6·7	6·6	6·2	7·1	6·5	6·1	6·6	7·6	7·9
27	6·4	7·5	7·2	6·6	6·4	5·8	7·2	6·6	6·3	6·9	7·2	7·6
28	6·6	7·2	7·4	7·1	7·1	6·8	7·2	6·4	6·2	6·6	6·8	7·6
29	7·2		6·3	6·7	7·0	6·3	6·6	6·1	6·4	7·5	6·5	7·7
30	7·8		6·9	6·0	6·4	6·8	6·5	5·9	6·9	7·5	7·1	7·8
31	7·1		6·7		6·4		6·5	5·9		6·8		7·5
Greatest daily value.	8·3	8·0	7·7	7·2	7·2	7·5	7·4	7·0	7·0	7·5	7·8	8·1
Least daily value.	6·4	6·9	6·3	5·8	5·8	5·6	5·9	5·8	5·6	6·1	6·4	6·6
Range in month.	1·9	1·1	1·4	1·4	1·4	1·9	1·5	1·2	1·4	1·4	1·4	1·5
Mean.	7·41	7·41	6·95	6·57	6·50	6·59	6·68	6·49	6·25	6·83	7·05	7·43
Mean of the twelve monthly values = 6·85												

The daily values of cloud for the fifty years in question were transcribed so that there appeared in one vertical column the fifty values for January 1 of the different years, in the next column the fifty values for January 2, and so on, from which the mean value for each day of the year was formed. It should be explained that during the years 1841 to 1847 each separate daily mean depends on twelve two-hourly observations, excepting on Sundays and some other occasions when fewer observa-

tions were taken, on which days these were supplemented by incorporating therewith the observations of the Belville Greenwich record, the originals of which are in the possession of the Society. In 1848 the results depend on six observations daily, and from 1849 to 1890 on four observations daily, those on Sunday being taken at slightly different hours. The daily means from 1841 to 1847 are given in the printed Greenwich volumes, excepting for Sundays and some other days, for which values were prepared as already described. No daily values for succeeding years having been published, I am indebted to the Astronomer Royal for permission to use them for the purpose of this paper.

The actual observations were made by many different observers, several being at all times employed. When any observer leaving was replaced by a new one, the latter was instructed by the older observers in their manner of estimating the amount of cloud. By this means the introduction of personality in observation was to a great extent avoided, whilst the employment at all times of several observers tended to preserve continuity of method. The usual notation was throughout employed, 0 signifying a clear sky, and 10 one that is overcast.

The collected mean values for each day of the year, as deduced from the observations of the fifty years, are given in Table I., and they are exhibited graphically in the diagram (Fig. 1, p. 172). It will be readily seen, both by the table and in the graphical representation, that a principal maximum occurs in winter and a principal minimum in autumn, with a secondary much less pronounced maximum in summer and a secondary minimum in spring; and when the whole series is divided into two of twenty-five years each the same characteristics are shown. But there is considerable irregularity in the succession of daily values, the differences between which on consecutive days (see Table I.) are in numerous cases relatively large, considering that the results are derived from the observations of fifty years. That such irregularity exists is in itself information. In order to ascertain whether there is any seasonal difference in this irregularity, the differences between the values of each one day and the next in Table I. were taken throughout each month, and the mean for each month of the numbers so found is given in Table II.

TABLE II.—MEAN VARIATION OF AMOUNT OF CLOUD BETWEEN ONE DAY AND THE NEXT, IN EACH MONTH.

January	0.37	July	0.35
February	0.39	August	0.26
March	0.39	September	0.41
April	0.27	October	0.40
May	0.30	November	0.36
June	0.39	December	0.37

It should be mentioned that there is considerable variation in some cases between different parts of the same month. But on the whole the numbers appear to show a tendency to a prolonged maximum in winter, a second more moderate maximum in summer, with minima in spring and autumn. The value for September seems somewhat large, the month being meteorologically one rather of quiet character. In this connection

ROYAL OBSERVATORY, GREENWICH.

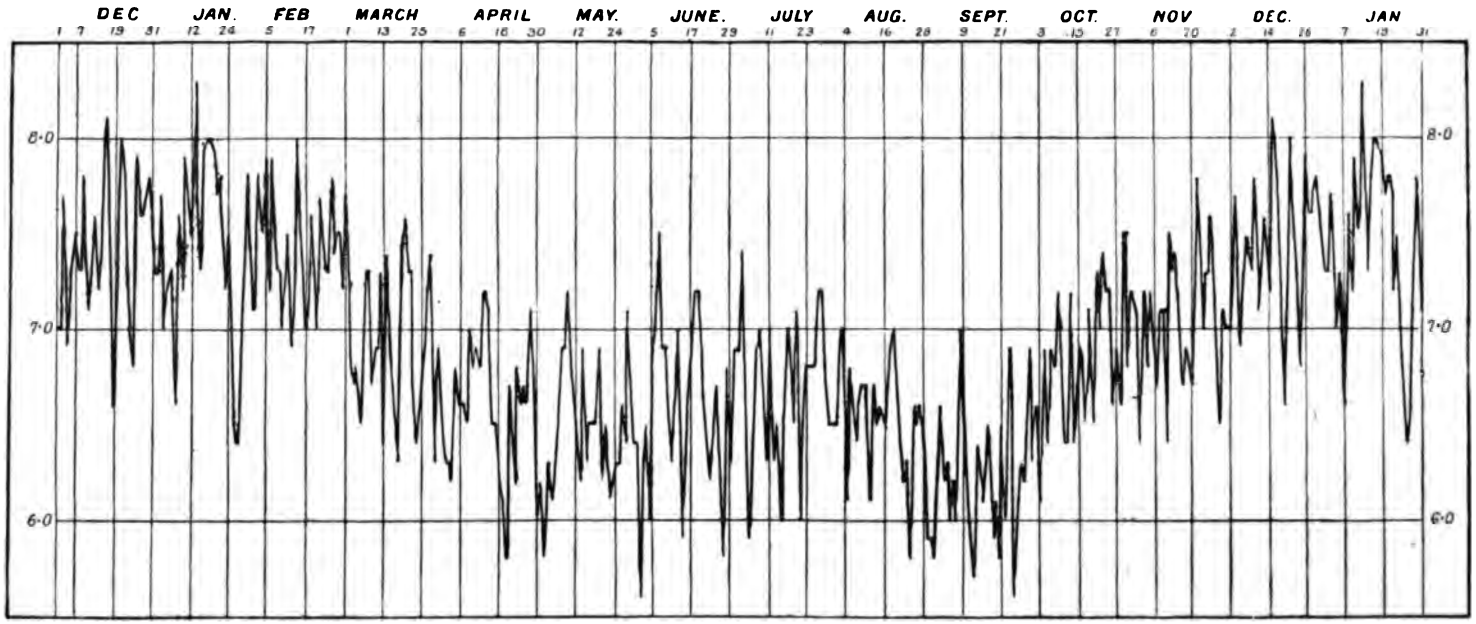


FIG. 1.—Curve of Mean Amount of Cloud on each Day of the Year, as found from the Observations of the Fifty Years, 1841-1890.
Mean Amount of Cloud for the Year = 6·85.

it may be remarked that there is a greater prevalence of wind storms during the winter half of the year.

It may be thought to be refining too much to treat cloud observations in this way, considering that the amount of cloud is usually estimated only to the nearest unit. It gives some information on this point to divide the observations of the fifty years into two series of twenty-five years each. This was done, and the separate monthly means thus found are given in Table III.

In seven months of the year the difference between the two monthly values does not exceed 0·10, showing that a second decimal place in these months is by no means redundant. The differences in the remaining five months are greater, but they probably indicate definite variations in amount of cloud. The greatest difference exists in May, 0·38, but the values in the preceding and following months of April and June are in close agreement, and observers would not in two periods so vary in their estimate of the amount of cloud in three successive months so similar in general character as April, May, and June. It happens that numerous high

TABLE III.—MEAN MONTHLY AMOUNT OF CLOUD IN TWO TWENTY-FIVE YEARLY PERIODS.

Month.	Mean Amount of Cloud.	
	1841-1865.	1866-1890.
January	7·44	7·38
February	7·30	7·53
March	7·00	6·91
April	6·53	6·61
May	6·69	6·31
June	6·60	6·59
July	6·73	6·63
August	6·57	6·40
September	6·20	6·30
October	6·96	6·69
November	7·16	6·93
December	7·44	7·43
Mean	6·89	6·81

values for May occur during the first twenty-five yearly period (*Quarterly Journal*, vol. xiv. p. 187), varying in the years 1845, 1852, 1856, and 1862 from 8·0 to 8·3, whilst also the least May value recorded since the commencement of observation in 1818, viz. 3·0 in 1848, occurs during the same period, which does not indicate any tendency to over-estimate at about that time. The low value of 3·0 is itself corroborated by the circumstance that the temperature of May 1848 was unusually high, as is likely to be the case in May when the amount of cloud is small.

In order to reduce to some extent the irregularities of Table I., and so better bring out the principal features of the annual variation, five-day means were formed (Table IV.), from which was constructed the graphical curve (Fig. 2, p. 175).

The principal maximum in the five-day means occurs January 16 – 20 = 7·88 : the principal minimum is double, August 29–September 2, and September 18 – 22, both = 6·06 : the secondary maximum occurs June

5 – 9 = 7·06, and the secondary minimum May 1 – 5 = 6·14. The variations of short period are still considerable in all months excepting October. The observations of many years will evidently be necessary to eliminate from the curve the irregularities that are presumably of accidental character.

TABLE IV.—FIVE-DAY MEANS OF AMOUNT OF CLOUD.

January	1	—January	5	7·30	June	30	—July	4	6·90
,,	6	,,	10	7·32	July	5	,,	9	6·66
,,	11	,,	15	7·72	,,	10	,,	14	6·42
,,	16	,,	20	7·88	,,	15	,,	19	6·64
,,	21	,,	25	7·42	,,	20	,,	24	6·58
,,	26	,,	30	6·90	,,	25	,,	29	6·98
,,	31	February	4	7·42	,,	30	August	3	6·66
February	5	,,	9	7·52	August	4	,,	8	6·46
,,	10	,,	14	7·34	,,	9	,,	13	6·58
,,	15	,,	19	7·28	,,	14	,,	18	6·64
,,	20	,,	24	7·36	,,	19	,,	23	6·52
,,	25	March	1	7·52	,,	24	,,	28	6·38
March	2	,,	6	6·82	,,	29	September	2	6·06
,,	7	,,	11	7·02	September	3	,,	7	6·14
,,	12	,,	16	7·00	,,	8	,,	12	6·36
,,	17	,,	21	7·04	,,	13	,,	17	6·20
,,	22	,,	26	6·80	,,	18	,,	22	6·06
,,	27	,,	31	6·90	,,	23	,,	27	6·36
April	1	April	5	6·40	,,	28	October	2	6·48
,,	6	,,	10	6·70	October	3	,,	7	6·62
,,	11	,,	15	7·04	,,	8	,,	12	6·70
,,	16	,,	20	6·22	,,	13	,,	17	6·74
,,	21	,,	25	6·42	,,	18	,,	22	6·94
,,	26	,,	30	6·62	,,	23	,,	27	7·06
May	1	May	5	6·14	,,	28	November	1	7·12
,,	6	,,	10	6·82	November	2	,,	6	6·92
,,	11	,,	15	6·54	,,	7	,,	11	6·98
,,	16	,,	20	6·52	,,	12	,,	16	7·16
,,	21	,,	25	6·30	,,	17	,,	21	6·90
,,	26	,,	30	6·70	,,	22	,,	26	7·40
,,	31	June	4	6·16	,,	27	December	1	6·92
June	5	,,	9	7·06	December	2	,,	6	7·24
,,	10	,,	14	6·44	,,	7	,,	11	7·40
,,	15	,,	19	6·82	,,	12	,,	16	7·64
,,	20	,,	24	6·62	,,	17	,,	21	7·40
,,	25	,,	29	6·36	,,	22	,,	26	7·36
					,,	27	,,	31	7·64

An examination was made into the distribution of days in different months as regards degrees of amount of cloud, tabulating for this purpose the number of days in each month that the sky was either cloudless or overcast, or on which the amount of cloud was included within certain limits. Thus days having an amount of cloud between 0·1 and 3·0 were considered as days of little cloud, days with amount of cloud between 3·1 and 8·9 as days of medium cloud, and days with amount of cloud between 9·0 and 9·9 as days of much cloud. The results are given in Table V., in which, on account of the inequality in the length of different months, the percentage of days of each class of cloud in each month is given, instead of the actual number of days.

The table is to be thus read. In January in 50 years there are 1550 days, in each 100 days of which there were on the average 2 days cloudless, 8 days of little cloud, 46 days of medium cloud, 15 days of

much cloud, and 29 days overcast. And similarly for other months, and for the year.

TABLE V.—PERCENTAGE OF DAYS OF DIFFERENT DEGREES OF CLOUD IN EACH MONTH FROM OBSERVATIONS MADE DURING THE PERIOD 1841-1890.

Month.	Cloudless 0.0	Little Cloud 0.1 to 3.0	Medium Cloud 3.1 to 8.9	Much Cloud 9.0 to 9.9	Overcast 10.0
January	2	8	46	15	29
February	2	8	46	16	28
March	3	9	55	13	20
April	5	11	55	14	15
May	3	12	59	12	14
June	3	12	59	14	12
July	2	11	63	15	9
August	3	10	65	13	9
September	5	12	60	12	11
October	2	12	53	13	20
November	2	11	49	14	24
December	1	10	43	15	31
The Year	3	10	54	14	19

The cloudless days are most numerous in spring and autumn, and least so in winter and summer, though the variation in this respect through the year seems scarcely so great as might have been expected. The days of little cloud are somewhat less numerous in winter as compared with other parts of the year, in which there is little variation, whilst the days of medium cloud are much more numerous in summer than in winter. The days of much cloud are nearly equal in amount in all parts of the year. The overcast days are much more numerous and

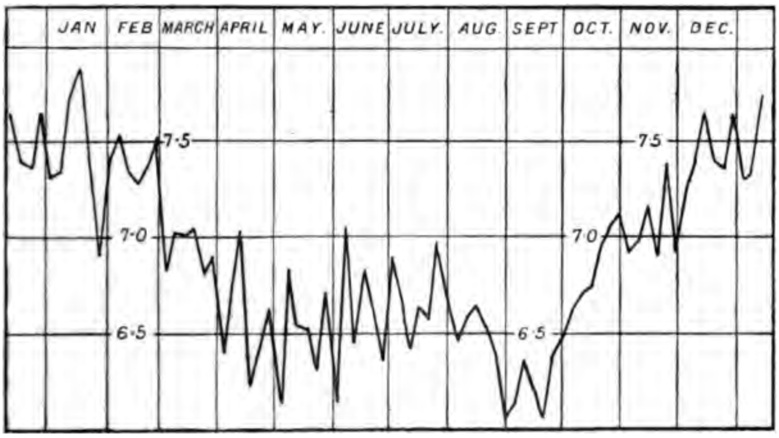


FIG. 2.—Five-day Means of Amount of Cloud, 1841-1890.

nearly equal in amount in the first and fourth quarters of the year, much less numerous in the second quarter, and again less numerous in the third quarter. The distribution of days of different degrees of cloud is altogether very similar in the months of December, January, and February; and in March and October differs very little from the dis-

tribution for the year as a whole. It will be observed that the decrease in the number of overcast days as summer is approached is accompanied by a nearly equal increase in the number of days of medium cloud, and by scarcely any change in the number of days of much cloud. That is to say the lesser number of overcast days of summer is supplemented, not by an increase in the number of days of much cloud (rather indeed by a slight decrease), but by increase in the number of days of medium cloud, and some increase in those of little cloud.

An inquiry into the character of the relation existing between cloud observations and sunshine records has furnished results which may be thought interesting. In the circumstances influencing the two records there is this difference, that whilst the amount of cloud varies only with the time of year, the proportion of sunshine varies not only with the time of year (that is as affected by the amount of cloud), but also with the altitude of the sun. If the sunshine records could be taken as actually measuring the amount of clear sky, as the cloud observations are a measure of the amount of cloud, the two records should yield complementary results. Thus constant sunshine on any day being represented by 0 of cloud, and no sunshine by 10 of cloud, partial sunshine would be represented by a corresponding complementary amount of cloud. And this appears to be nearly the case in months in which the sun reaches daily a considerable altitude. But in months in which the altitude attained is lower, the sunshine registered is not fully complementary of the observed amount of cloud, but falls short thereof. To illustrate this, the mean monthly values of amount of cloud for the fifteen years, 1877 to 1891, have been compared with the mean monthly proportion of sunshine (constant sunshine = 1) for the same period, one adopted simply because the corresponding mean monthly proportion of sunshine for Greenwich was readily obtainable from my previous paper, to be found in the *Quarterly Journal*, vol. xix. p. 118. The comparison is made on the supposition that the cloud and sunshine results are really complementary. The cloud scale is numerically ten times that of the sunshine scale, therefore by dividing the mean amount of cloud for each month by 10 and taking the complement of the quotient to 1, we obtain the amount of clear sky on a scale of 0 to 1. This is compared in Table VI.

TABLE VI.—GREENWICH CLOUD AND SUNSHINE RECORDS COMPARED, 1877-1891.

Month.	Mean Altitude of Sun at Noon.	Observed Mean Amount of Cloud.	$1 - \frac{\text{Cloud}}{10}$ = Clear Sky.	Mean Registered Proportion of Sunshine.	Residual.
January . .	18°	7·37	0·263	0·106	−0·157
February .	26	7·45	0·255	0·156	−0·099
March . .	37	6·87	0·313	0·256	−0·057
April . .	48	6·97	0·303	0·293	−0·010
May . .	57	6·44	0·356	0·366	+0·010
June . .	62	6·63	0·337	0·350	+0·013
July . .	60	6·93	0·307	0·333	+0·026
August . .	52	6·66	0·334	0·340	+0·006
September .	41	6·34	0·366	0·310	−0·056
October . .	30	6·68	0·332	0·241	−0·091
November .	20	7·01	0·299	0·161	−0·138
December .	16	7·35	0·265	0·087	−0·178

with the corresponding monthly mean proportion of sunshine obtained from the paper mentioned, adding in another column of the table the mean altitude of the sun at noon in each month. The record is that of *bright* sunshine, registered until 1886 by the Campbell recorder, and from 1887 by the Campbell-Stokes recorder.

It thus appears that in the five months of April, May, June, July, and August, in each of which the sun at noon at Greenwich reaches daily a considerable altitude, the cloud and sunshine records are practically complementary, the residuals in the last column of the table being in these months on the whole small. It would seem that when a noon altitude of about 45° is reached, and from that to altitude 62°, the sun at Greenwich obtains such command of the sky that the monthly proportion of sunshine closely represents the proportion of clear sky. What would happen did the sun at Greenwich attain a noon altitude greater than 62°, whether or not the relation would undergo further change, cannot by observation be known, but since the proportion of sunshine at low altitudes falls considerably below that of clear sky, whilst it more nearly approaches thereto as the altitude of the sun increases, until between altitudes 45° and 62° the proportion of sunshine nearly represents that of clear sky, it may be that the limit of change in the relation is then nearly reached. The rapid variation in the proportion of sunshine at lower altitudes would seem to be more a consequence of difference of altitude of sun than of variation in amount of cloud. In Table VII. months that have very nearly similar amounts of cloud, but different altitudes of sun, are compared; and in Table VIII. months that have similar altitudes of sun, but different amounts of cloud.

TABLE VII.—Variation of Sunshine in Months having similar Amount of Cloud, 1877-1891.

Month.	Mean Altitude of Sun at Noon.	Observed Mean Amount of Cloud.	Mean Registered Proportion of Sunshine.
	°		
November	20	7·01	0·161
March	37	6·87	0·256
April	48	6·97	0·293
July	60	6·93	0·333

The increase in the proportion of sunshine with increase of altitude is evident. It is not easy to compare months having the same altitudes of sun and different amounts of cloud, except by combining, in some cases, two months together, as in Table VIII.

Table VIII. shows that, with similar altitude of sun, the months having a lesser amount of cloud have a corresponding greater proportion of sunshine, whilst Table VII. shows that, with similar amount of cloud, the proportion of sunshine increases rapidly with increase of altitude when the altitude is low, but much less rapidly when the altitude is higher. It is to be remarked that the residuals at high altitudes (Table VI.) indicate that the proportion of sunshine is somewhat more than complementary of the observed amount of cloud, although it is known that the sunshine record is subject to a slight loss of register on those occasions on which

the sky near the horizon happens to be clear at sunrise or sunset. It seems easy to understand why more sunshine should be registered with increased altitude. At higher altitudes the straight line joining the sun and the sunshine recorder tends to a vertical direction, whilst at lower

TABLE VIII.—VARIATION OF SUNSHINE IN MONTHS HAVING SIMILAR ALTITUDE OF SUN, 1877-1891.

Month.	Mean Altitude of Sun at Noon.	Observed Mean Amount of Cloud.	Mean Registered Proportion of Sunshine.
March } April }	42°	6·92	0·274
September	41	6·34	0·310
May } June }	60	6·54	0·358
July	60	6·93	0·333

altitudes it tends to a horizontal direction, and we can very well imagine that, on days of variable or broken cloud, of which we have so many, much more sunshine would be likely to reach the recorder in the former than in the latter case.

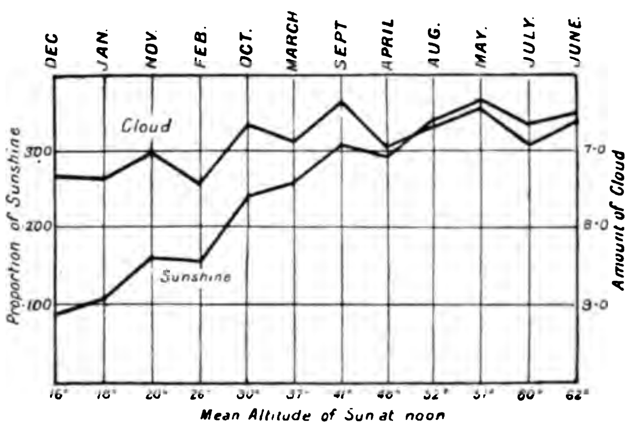


FIG. 3.—Cloud and Sunshine, 1877-1891, arranging the Months in order of magnitude of Sun's Altitude.

Some points in the comparison of cloud and sunshine results can be better seen in a graphical representation. In the accompanying diagram the months are arranged not in order of months, as in Table VI., but in order of magnitude of the sun's altitude at noon. The scales of cloud and sunshine run in opposite directions, by which it is readily seen how closely the values become complementary at the higher altitudes, and also, notwithstanding the divergence of the curves at the lower altitudes, how the rise or fall of either curve between any two adjacent altitudes is throughout accompanied by corresponding rise or fall of the other, showing that, apart from the general change of direction of either curve, their irregu-

larities (due to climatic variation) are of similar character, and in this sense the curves are entirely corroborative.

The residuals in the last column of Table VI. show that a given relation between the cloud and sunshine records holds for a limited time, for a longer period when the sun's altitude is high, and for shorter periods when it is low. There being little change during summer, and the records being also nearly complementary, it appeared that although they had so far been treated only for complete months, a comparison in summer for days seemed also possible, and in order to see within what limits daily values would accord, selection was made of the month of May in the year 1889, May being taken as the most sunny month, and 1889 as a year in which the sunshine registered in this month, was near the average value. No other month was tried. The residual for May (Table VI.) being small, the comparison was made on the supposition that the records were strictly complementary. The particulars are given in Table IX. It will be remarked that the values of cloud inferred from the sunshine records are in good agreement with the observed values, being on 22 days out of 31 within one unit of the scale of cloud numeration, an accordance between daily values hardly to be expected. The mean difference 0·1 is very small.

TABLE IX.—GREENWICH CLOUD AND SUNSHINE RECORDS COMPARED FOR THE MONTH OF MAY 1889.

Day.	Registered Proportion of Sunshine.	10 (1 − Sunshine) = inferred Amount of Cloud	Observed Amount of Cloud.	Residual.
1	0·17	8·3	8·2	+0·1
2	0·27	7·3	6·8	+0·5
3	0·59	4·1	5·2	−1·1
4	0·59	4·1	3·3	+0·8
5	0·60	4·0	3·3	+0·7
6	0·68	3·2	3·0	+0·2
7	0·43	5·7	7·2	−1·5
8	0·47	5·3	5·5	−0·2
9	0·23	7·7	8·3	−0·6
10	0·07	9·3	9·2	+0·1
11	0·00	10·0	10·0	0·0
12	0·00	10·0	10·0	0·0
13	0·00	10·0	10·0	0·0
14	0·14	8·6	9·2	−0·6
15	0·42	5·8	6·0	−0·2
16	0·67	3·3	0·0	+3·3
17	0·16	8·4	8·5	−0·1
18	0·39	6·1	7·5	−1·4
19	0·04	9·6	10·0	−0·4
20	0·17	8·3	6·2	+2·1
21	0·55	4·5	4·5	0·0
22	0·65	3·5	1·0	+2·5
23	0·55	4·5	4·7	−0·2
24	0·83	1·7	2·3	−0·6
25	0·29	7·1	8·5	−1·4
26	0·00	10·0	10·0	0·0
27	0·00	10·0	10·0	0·0
28	0·13	8·7	9·2	−0·5
29	0·61	3·9	5·3	−1·4
30	0·75	2·5	5·7	−3·2
31	0·63	3·7	4·5	−0·8
		Mean		−0·1

If we divide the days in Table IX. into two groups, combining in one group the values of sunshine less than the average (0·36), and in the other group the values greater than the average, we find that on 15 days with mean proportion of sunshine = 0·11, corresponding to inferred amount of cloud = 8·9, the mean observed amount was also 8·9; and on 16 days with mean proportion of sunshine = 0·59, corresponding to inferred amount of cloud = 4·1, the mean observed amount was 4·3.

The cloud and sunshine results in May 1889 are thus complementary, both for small and large values of sunshine. But probably every summer month would not give so close an agreement. No such comparison is possible in winter, little sunshine being on occasions registered when there may be considerable clear sky.

It may be interesting to express definitely the relation between the cloud and sunshine records, as given by the results for the period 1877-1891. Calling the proportion of sunshine = S, and the amount of cloud = C, we have $C = 10(1 - S \times \text{factor})$. The factors for the different months founded on the numbers of Table VI., equal in each month to $\frac{1 - \frac{C}{10}}{S}$, are:—

January	2·48	May	0·97	September	1·18
February	1·63	June	0·96	October	1·38
March	1·22	July	0·92	November	1·86
April	1·03	August	0·98	December	3·05

The factors from April to August differ little from unity. That for December, 3·05, well represents our estimation of this month as one of the most gloomy of the year. In the early and late portions of the year the factor can only be considered as applying to about the middle of the month.

It would be interesting to ascertain in what respect the relation between cloud and sunshine is different in tropical regions. As I was about completing this paper, I happened to receive the results of the meteorological observations made at the Mauritius Observatory during the year 1894. The observations of a single year, even in the tropics, are not sufficient to give normal values, but the main features of the relation can be ascertained. The conditions are quite different from those existing in our latitude. The meridian altitude of the sun at Greenwich varies from 16° in December to 62° in June; at the Mauritius it varies from 47° above the northern horizon in June to 87° above the southern horizon in December, that is, in the Mauritius summer the sun comes to the meridian on the south side of the zenith, Mauritius being situated within the southern tropic. Thus the meridian altitude of the sun at Greenwich is never, in any month, above 62°, whilst at Mauritius it is never below 47°. Comparing together the results for the two extreme yearly positions at the two places, taking the average of the three months of November, December, and January, and of the three months of May, June, and July, the mean values of cloud at Mauritius are found to be 6·23 and 5·07 respectively, and of proportion of sunshine 0·597 and 0·657 respectively. Using these numbers for Mauritius, and corresponding numbers deduced from Table VI. for Greenwich, the factors in the formula $C = 10(1 - S \times \text{factor})$ are found to be as follows:—

Period of Year.	Greenwich—15 years. Mean Factor.	Mean Altitude of Sun at Noon.	Mauritius—1 year. Mean Factor.	Mean Altitude of Sun at Noon.
November, December, January	2·34	18°	0·63	90°
May, June, July	0·95	60°	0·75	49°

The difference between the two values of the factor at Mauritius, although small, is real, since the separate monthly values show distinctly an annual variation. At both Greenwich and the Mauritius the factor decreases with increase of altitude of the sun, and further, the comparatively small decrease at the high altitudes of the Mauritius seems to bear out what was indicated by the Greenwich results, that at the higher altitudes the factor had nearly reached the limit of change. It will be remarked that, for a given altitude, the factor is evidently much smaller at Mauritius than at Greenwich. For instance at altitude 60° at Greenwich the factor is 0·95, and it is easy to see that for the same altitude at Mauritius the factor would be less than 0·75. But this is quite what might be expected. At Mauritius the altitude of the sun more rapidly increases after rising, and more rapidly decreases towards sunset, than at Greenwich, owing to the greater inclination of the sun's path towards the horizon at the latter place, in consequence of which, in variable conditions of the sky, the sun would be for a much shorter time entangled with cloud in the morning and evening at Mauritius than at Greenwich. It is also probable, as regards Greenwich, that the apparent check in the decrease in the value of the factor in summer (see the values from April to August) is, to some extent, due to the circumstance that the decrease becomes retarded because of the greater inclination of the sun's path towards the horizon in summer than in spring or autumn, which causes the sun to be somewhat longer in reaching a definite altitude in summer than in spring or autumn, tending thus to reduce somewhat the summer sunshine. The corresponding local effect at the Mauritius would be much less pronounced.

The foregoing comparison of cloud and sunshine results may by some be considered to be fanciful, but it is perhaps interesting as illustrating the nature of the relation that exists between them at different parts of the year, and at different places, as influenced mainly by the altitude of the sun. The relations actually worked out have little practical value, since cloud and sunshine must each be independently determined by direct observation. Besides which, the relations are such as apply only to the place of observation, or to a place in the same latitude, having also nearly similar meteorological conditions.

DISCUSSION.

The President (Mr. E. Mawley) said that much praise was due to Mr. Ellis for his communication. Papers of this kind were most valuable, as the whole of the observations had been made at the same place, on an uniform system, and extended over a considerable number of years. Of all non-instrumental observations—those which depend in a great measure upon the

judgment of the observer—none were, in his opinion, as reliable as those having reference to the amount of cloud. He was rather surprised to find that the effects of the increase of London smoke were not to be traced in the means given in Table III. On the contrary, according to the results there given, the sky was rather less obscured during the second half of the fifty years than in the first. Not only was this the case in the summer months, but also during the three dullest months of the year as well.

Mr. F. C. BAYARD said that the diagram showing the curve for the mean amount of cloud on each day of the year would be much more interesting if a line were drawn to show the mean amount in each month, for the purposes of comparison. He could hardly understand how the factors were obtained. An explanation of this point by Mr. Ellis would, he thought, be valuable and instructive.

Mr. R. INWARDS inquired if records of hourly variation of sunshine and cloud were obtainable. With regard to the decrease of cloud with the sun's altitude, did Mr. Ellis think it really a decrease, or merely the facility with which the more vertical rays penetrated the layers of cloud?

Mr. G. J. SYMONS thought that there was such an amount of work in the paper that it would have been better if it had come before the Society in two separate papers: (1) On the Mean Amount of Cloud, and (2) On the Relation between Records of Cloud and of Sunshine. In 1850 Mr. Glaisher published "Diurnal Range Tables" for converting observations to mean daily values, and they were still largely in use. It would be interesting to know how far they agree with Mr. Ellis's results. In the winter season, when for sixteen hours out of the twenty-four the sun was below the horizon, the lines on Fig. 3 were very divergent, but in the summer months they ran fairly well together. Perhaps the explanation of this was that, in the summer, two-thirds of the observations were made while the sun was above the horizon, and the periods were more nearly synchronous.

Mr. R. H. CURTIS said that he had drawn a generalised curve over Mr. Ellis's curve of mean daily amounts of cloud, and also over that of five-day means, and these generalised curves were almost identical in the two cases. He had also plotted upon the five-day curve (Fig. 2) a curve showing the mean amount of sunshine recorded at Kew Observatory for each month during the ten years 1881-90, expressed as a percentage of the greatest possible amounts; the values being those he had used for his paper on the "Diurnal Variation of Sunshine," read before the Society last June. The curve formed by these means has almost the exact complement of the generalised curve of mean cloudiness—a decrease in the percentage of sunshine, as in June and July, corresponding to an increase in the amount of cloud in these months, and an increase in sunshine, as in August, accompanying a marked decrease in cloud. But there was one important exception in September, which was shown by Mr. Ellis to be the least cloudy month of the year, although the amount of sunshine fell to almost the same percentage as in April, which was apparently a much more cloudy period. With reference to the daily means of cloud he thought it unsafe, with such a variable element, to attach very great weight to means for such short periods, and the more so as the means were based on but a few observations per diem. Under such conditions it was inevitable but that great variations should be shown in the means, and he thought it would be unsafe to regard them as indicating the true variation from day to day. This conclusion was, he thought, borne out by the great smoothing down which the fluctuations underwent when the slightly longer period of five days was dealt with.

Mr. F. J. BRODIE was of opinion that scarcely enough stress had been laid on the fact that the record of sunshine given by the Campbell-Stokes instrument was one of *bright* sunshiue only, and that in the winter time it was quite possible

for a day to be perfectly cloudless without any record being shown on the card. The fact doubtless accounted in a large measure for the discrepancies shown between the amount of cloud and the duration of bright sunshine at a time of year when the sun is at a low altitude. At such seasons the sun's rays were too feeble to pierce the mists which so often hang about, more particularly in the neighbourhood of London.

Mr. R. H. SCOTT inquired whether Mr. Ellis knew if the Pickering Pole Star recorder, for the determination of the amount of cloud at night, was in use at any meteorological station in the British Isles.

Mr. W. ELLIS said, in regard to the hourly variation of cloud, that no observations which could be usefully employed for determining hourly variations had been made at Greenwich since those taken every two hours, day and night, during the years 1841 to 1847, the mean results of which for each month of the year are to be found in his address to the Society, *Quarterly Journal*, vol. xiv. p. 195. Mr. Glaisher's diurnal range table, which he (Mr. Ellis) had not seen, was probably founded on the same series of observations, and there are no other observations available for making a complete determination of the hourly variation of cloud. The hourly variation of sunshine he had dealt with in papers in the *Quarterly Journal*, vol. iii. p. 464, and vol. vi. p. 128, as also had Mr. Curtis in his paper in vol. xxi. p. 216. There is a decrease of cloud with the monthly increase of the sun's altitude, as summer is approached, which is a seasonal effect, but in the diurnal variation there is at all times of the year, excepting mid-winter, a somewhat greater amount of cloud by day than at night, the maximum amount occurring towards mid-day. Respecting the factors for inferring the amount of cloud from the observed proportion of sunshine, a modification of the sentence in which the factors are spoken of would be made, so as better to show how they are obtained. It has been remarked, as probably explaining the divergence of the curves in Fig. 3 in winter, that the sun being at this period of the year for so short a time above the horizon, the observations of cloud and sunshine were probably not sufficiently synchronous. Such a view might be taken if we were considering individual days or short periods of time, but not when observations are dealt with in the mass. Employing the table showing the diurnal variation of cloud, before spoken of, *Quarterly Journal*, vol. xiv., and forming the mean value of cloud for the period comprising the months of November, December, and January, during which the divergence of the curves in Fig. 3 is greatest, and including only the hours of 9, 11, 13, and 15 of civil time, that is, those from 9 a.m. to 3 p.m., which represent the winter solar day, the mean amount of cloud is found to be 7·55, that for the same three-monthly period, including all the two-hourly observations, being 7·43, differing only by about the one-sixtieth part: indicating that the effect of the cloud observations extending, in winter, over a relatively longer interval than the sunshine record, would not perceptibly alter the winter relation of the two curves of Fig. 3. It is to be understood that the sunshine is throughout the percentage of the possible amount. It may be also mentioned that in the Greenwich annual volumes it is distinctly stated that the register is that of "bright sunshine," which is that really beneficial to animal and vegetable life. He demurred to the statement that a day may be perfectly cloudless without any record being shown on the card. In such condition of sky (excepting very near to sunrise or sunset) surely the sun cannot but register. There are days, not exclusively in winter, on which the sun will be visible through haze or mist without producing register, but this state of sky cannot be said to be perfectly cloudless. Further, it appears that sunshine may be registered as near to the horizon in winter as at other parts of the year, as he had pointed out at p. 133 of his paper in vol. vi. of the *Quarterly Journal*. There appears, indeed, not to be such difference

in the sun's power but that, with a clear sky, register becomes effective at all parts of the year (always excepting when near the horizon). In a partially cloudy state of the sky, however, so often the prevailing condition, the clear sky becomes more obstructed towards the horizon than towards the zenith, causing the sunshine register to be relatively interfered with to a greater extent in winter than at other times, as indicated in Tables VI. and VII. and Fig. 3. Mr. Curtis spoke of having compared a generalised curve of Greenwich cloud with values of Kew sunshine as used by him for constructing the sunshine curves given in his paper before noticed, but Mr. Ellis not having seen the generalised curve, and not knowing the Kew values, could offer no remarks thereon. He had always regretted that Mr. Curtis's paper did not include in a tabular shape the complete numerical values of Kew sunshine, since the ten-yearly means would probably not have occupied much space. In regard to the comparison made, Mr. Ellis thought it scarcely satisfactory to compare together Greenwich cloud and Kew sunshine, or even to compare at all Greenwich and Kew results founded on different series of years. As to the irregularities of Table I., he did not suppose that any one would consider them as other than mainly of accidental character. The paper itself states that many years' observations will evidently be necessary to eliminate irregularities presumably accidental. His use of the numbers in Table II. may have produced an impression that undue importance was attached to them, but it was simply that he thought that, as they stood, the numbers might still be used to compare the relative irregularities of different parts of the year. The question of more or fewer daily observations of cloud, although it would have influence in short periods, would not much affect the daily irregularities of fifty years' means: it is a longer series of years that is mainly required. In reply to Mr. Scott, he did not know of any instance in which the Pickering Pole Star recorder had been used in the British Isles, that is, for the systematic observation of cloud by night.

ATMOSPHERIC DUST OBSERVATIONS FROM VARIOUS PARTS OF THE WORLD.

By E. D. FRIDLANDER, B.Sc.

[Read April 15, 1896.]

In the following account of some observations of the amount of dust in the atmosphere made at various places during a voyage round the world, I can only add a few small items to the knowledge we already have upon the subject; and though certain of the results give for the first time some information respecting the distribution of dust on the open ocean, and in mountain regions at altitudes of from 6000 to more than 13,000 feet, they yet form in the main an independent confirmation of some of the conclusions arrived at by Mr. Aitken in 1889 (vide *Proceedings Royal Society, Edinburgh*, vol. xvii.).

All the experiments were made with a form of Mr. Aitken's Pocket Dust Counter, and for the sake of those who are not acquainted with it, I will give a brief description of the instrument and the method of its use.

The dust counter consists essentially of a chamber into which air can be introduced, saturated with water vapour, then slightly and

quickly cooled. Owing to the fall of temperature condensation of vapour takes place on the dust nuclei, which then fall on to a micrometer plate at the bottom of the chamber, where they are rendered easily visible for counting by the water layer which coats them.

The receiver of the pocket counter is a metal cylinder 1 centimeter deep and 3 centimeters in diameter, provided with a small pump, which serves the double purpose of cooling the air by sudden expansion, and of letting into the receiver a known proportion of the air to be tested.

The upper end of the cylinder (held vertically during an experiment) is permanently closed by a glass plate, through which the drops are viewed with a lens as they lie on the micrometer plate, which screws air-tight into the bottom of the cylinder.

When making a test, the dust initially in the air of the receiver is precipitated by a series of alternate expansions and condensations of the contained air on to the lower plate, where, the water being evaporated from it by the warmth of a finger held below the micrometer, it remains invisible, and produces no error in the subsequent counting of drops. (That this is true may be proved by freeing the air of dust, allowing the instrument to stand awhile, and then repeating the pumping, when it will be found that the water does not again condense on the nuclei that have fallen on the lower plate.)

A known proportion of this dustless air is then removed from the receiver by means of the pump, its place taken by the same amount of the air to be tested, and after the contents of the receiver have been mixed with a small stirrer, the dust is again made to fall as before, though this time one counts the number of drops that lie on 4 sq. mm. of the micrometer plate.

Supposing the distribution of the drops to be uniform, this number, which by suitable dilution of the air can be made to lie between 8 and 20, gives easily the quantity of dust per sq. centimeter that has fallen from a layer 1 cm. thick, *i.e.* the number of particles per cubic centimeter of the mixture in the receiver. Knowing the proportion of polluted to pure air in the cylinder, we have at once the amount of dust per cubic centimeter of the former.

There are many details connected with the instrument and its working which cannot be entered into here, and of which a full account will be found in a paper by Mr. Aitken in the *Proceedings of the Royal Society of Edinburgh* for 1890-91.

As an example of the working of the counter we may take the following case. It was found in one experiment that when the proportion of pure to polluted air was 9 to 1, that the number of drops on 4 sq. mm. was 10.

The number of particles per cc. of the mixture is here 250, and therefore the number per cc. of the undiluted air was 2500.

The observations below fall into two groups—firstly, those made in various parts of the world mostly on the ocean, and between July 1894 and March 1895; secondly, those made in Switzerland from June to September 1895.

The positions at which the ocean observations were made were, in the Atlantic set, only very roughly calculated from the ship's log; but

in those taken on the Pacific and other oceans, either they were made at or near to noon, or the approximate position of the vessel at the time of experiment was found for me by the navigating officer. It only remains to mention here, before proceeding to a general examination of the results which are tabulated at the end of this paper, that when crossing the Atlantic I was a mere novice in the use of the instrument, that but few external conditions were noted at this time, and that these results are probably affected with error (in some cases from local pollution), but I have still thought the figures sufficiently near the truth to be worth retaining.

On glancing over the figures below it will be noticed that there are differences, often large, between the results of the individual experiments of a given set, not only when, as on board ship, one's place of observation is continually moving, but also when all the experiments are made at the same station; and one is led to inquire how far these differences may be due to errors of observation, and how far to natural irregularity in the distribution of dust.

Now supposing that the temperature of the top and bottom of the chamber, and the saturation of the air it contains, are such as not to cause so rapid an evaporation of drops as to render their counting impossible, and that the illumination of the micrometer plate is good, so that all the drops to be counted can be clearly seen, then the principal source of error remaining lies in the leakage of outside air into the receiver, either by slipping past the piston of the pump during working, or by its being forced in during an expansion at the possibly imperfect joint of the lower counting plate.

But it will be remembered that before actually making a test, the air originally in the receiver is alternately expanded and condensed, until no more precipitation can be produced, a condition which evidently cannot be brought about if there be any leakage, as the dust introduced with the leaking air would cause a shower of drops at every downstroke of the piston. The mere fact, then, of our being able to make the air initially in the chamber dustless, renders the probability of leakage occurring during a test very small.

There is usually some irregularity in the distribution of drops on the counting plate, partly produced by the imperfect mixing of the two portions of air in the receiver, and partly perhaps by the small disturbing currents set up upon expansion. By rejecting, however, those observations in which the drops are obviously scattered on the micrometer very unevenly, the corresponding error may be made very small. We conclude, then, that the discrepancies mentioned above are mainly due to irregularities in the distribution of dust.

It will be seen from these experiments that not only does dust occur, as Mr. Aitken's work has shown, in the air of inhabited countries over the water surfaces immediately adjoining them, and up to an altitude of some 6000 or 7000 feet amongst the Alps of Switzerland, but it is found on the open ocean, and so far away from any land as to preclude the possibility of artificial pollution, and its existence has been directly demonstrated at a height of more than 13,000 feet.

Before considering some of the effects produced by dust in our atmosphere, it is desirable to examine what little information these and other

results furnish as to what may be the distribution and origin of dust in Nature, apart from those disturbing influences introduced by man.

Apart from the direct demonstration given by Mr. Aitken's experiments, and some of these quoted below of the large extent to which the atmosphere of the earth is polluted by artificial causes, it is evident that in and near to all centres of population the natural distribution of dust must be greatly modified; and indeed when one comes to see not only the amount of the pollution, but also the wide region over which it may be carried, one cannot help speculating as to whether any reliable information on the natural distribution of dust can be gathered, save from observations made either on those parts of large land areas far removed from all habitations, or from those made upon the open ocean.

Some idea of the amount of artificial pollution in a special case, and of the extent to which it may spread, can be gathered from Experiments 18 to 32 below, where it will be seen that while the average number of dust particles per cc. of air on the Pacific Ocean from October 30th to November 6th inclusive was 540 (the averages for the different days varying from 245 to 800), on November 7th, at about 350 miles from Auckland, the number rose to 1229, and that on November 8th, when about 15 miles from the Great Barrier Island, it was 1972, while the average of the too few observations taken in the North Island of New Zealand gives the value 1205.

The average dustiness of the Pacific air taken from *all* the observations but the two last above mentioned was 613, and that of the North Island of New Zealand, together with the polluted area outside of it, 1336. This difference would probably be much more marked were it not for the fact that the North Island is sparsely populated.

Even high mountains, unless rising from practically uninhabited regions, hardly afford satisfactory stations for these observations, as one can never be quite sure how far one's results are influenced by polluted air carried up from below. Mr. Aitken, working on the Rigi and elsewhere, has given many examples of the carriage of polluted air up mountains, and further evidence of the great height to which this may extend is found in several of the results below. Thus turning to Experiment 46 made on La Paraz, the highest point of the ridge forming the northern wall of the Vallèe des Ormonts, Switzerland, we find that the average dustiness of the air here at an altitude of 8360 feet was 2062; while the next day's observations in the valley 4400 feet below, taken under somewhat similar conditions, and quite away from the direct stream of polluted air from the village of Ormonts Dessus, gave the dustiness as 1958. The high value for the number of particles per cc. on the summit was probably due to the carriage of air from the "commune" below up the face of the ridge by the Southerly wind which was blowing across the valley at the time the experiments were made.

Again, it is difficult to imagine that the rather high number 1666 representing the dustiness on the summit of the Oldenhorn, 10,250 feet in altitude, and rather more than 6000 feet above the Vallèe des Ormonts, was not partly due to the mixing of impure lower air with the higher layers of greater purity, by the Westerly wind traversing the valley lengthwise from the village towards the mountain.

With regard to the variation of atmospheric dustiness with altitude, owing to the many ways in which the vertical distribution may be affected by artificial and natural causes, and to the scarcity of data, one can hardly say more than that in a calm atmosphere the quantity of dust per cc. in general diminishes as one ascends; and experiments made under nearly the same external conditions, but at different places, give such widely different results, not only for the dustiness at a stated altitude, but for its rate of change with variation of level, that it would seem hardly possible to arrive at any definite conclusions on this point.

At the Diablerets, for instance, at altitudes of 6000 and 5000 feet respectively, the amounts of dust per cc. were 2458 and 2937; but at Zinal, while the dustiness at 8200 feet was 481, that at 6700 feet was 950, giving a difference of 469 particles per cc. for a rise of 1500 feet, as compared with a change of 479 particles per 1000 feet in the former case.

The only set of tests given below in any way satisfactory in this respect is that of September 4th made on the Bieshorn, and though any attempt to formulate a general law for the vertical distribution of dust in a calm atmosphere from the result of a single day's observations in one region would be premature, it is still of interest to see to what these observations tend. The reasons for choosing the Bieshorn were that its position, height, and simplicity of ascent, render it very suitable for such observations. The first test was made shortly after reaching the summit of the mountain at 10.20 a.m., and the rest at various points on the descent. The Bieshorn forms part of the chain containing the Rothhorn and Weisshorn, rising about 9000 feet above the Zermatt Valley on its east, and some 8000 feet from that of Zinal on the west. Northwards, and some 2500 feet below its summit, lies a large covered glacier, while in a south-westerly direction stretches a region many miles in extent of snow-capped peaks and glaciers.

The result of the day's work summed up in the following table are represented by the curves accompanying it, whose ordinates are proportional to the amount of dust per cc. at altitudes denoted by the corresponding abscissæ. In the curve marked (2) allowance is made for the variation in the density of the air between the different points of observation. (These curves are not reproduced.)

It must be mentioned that the first two points on the curves represent the results of two experiments made on the day previous to that of the Bieshorn observations, and though these are not strictly comparable with the five remaining ones, their use is somewhat justified by the fact that they were made on the Bieshorn route from Zinal, and under nearly the same external conditions as those of the latter.

Height above sea-level.	No. of particles per cc.
6,700 feet	950
8,200 „	480
8,400 „	513
10,665 „	406
11,000 „	257
13,200 „	219
13,600 „	157

The abrupt change of value from 257 particles per cc. at the third to 406 at the fourth station where the difference of level was only 335 feet, can be accounted for by the imperfect mixing of upper and lower strata of air due to the form of the mountain at this part. The glacier sloped away very gently from the third to the fourth station, which latter was on the edge of a wall of loose rock running steeply down to a plateau some 2200 feet below, and over this edge the warm air from below blew in irregular gusts. Though the results seem to indicate, as will be seen from the curves, not only an increase in the amount of dust as one descends towards the valleys, but that the rate of change of dustiness with altitude becomes less as we ascend, the data are far too scanty to allow one to assume that this latter relation is generally true.

Some surprise may perhaps be felt at the relatively high value obtained for the number of dust particles per cc. at the top of the mountain, which may be partially explained, however, by the fact that the season in which these Swiss observations were made was a very hot and dry one, that there had been no rain for some days previous to that on which the tests were made, and that there was practically no wind at the time.

Turning now to the observations made on the Pacific and Indian Oceans, one is at once struck with the general purity of the air, especially in the latter of these two regions where the average number of dust particles per cc. for seven out of nine days was less than 500, and on five of these less than 400.

Much lower values than these have been obtained by Mr. Aitken at Kingairloch in the West Highlands, though almost invariably under conditions of rain, fog, and passing showers of mist, conditions which experiment proves to exercise a great purifying effect upon the atmosphere, whereas these ocean observations were taken for the most part in weather calm and fine, where no such obvious purifying agents were at work.

There is also a tolerable uniformity in the results obtained on successive days, especially marked on the Indian Ocean (side by side with the general uniformity of external conditions which characterised the voyage from Australia), and also noticeable in a less degree in the results from the Pacific, where the weather was on the whole not quite so uniform in character.

In illustration of the purifying effects in regard to dust brought about by rain and fog, we may turn to Experiments 36, 37, etc. Thus the lowest value 210 was found on the Indian Ocean after much rain. In Experiment 36 in the same region, we see that whereas at 10.30 a.m. the number of nuclei per cc. was 331, at 11.0 a.m. after a shower the number had fallen to 280.

Comparing the results of Experiments 37 and 38, the number obtained in the former of these in fine weather was 280, and from the latter, after much rain, 210.

Again, from the experiments of October 24th and 25th on the Pacific, we see that whereas the average dustiness on the former of these days was 529, on the latter, a showery day, it was 303.

Many tests made on the Atlantic, at Santa Cruz on the eastern margin of the Pacific, and in the Mediterranean off the island of Crete, give evidence of the clearing effects produced by fog. The results of the tests in the first of these regions are summarised as follows:—

No. of particles per cc.	Condition of air.
2000	Foggy at intervals.
3000	Thick fog.
420	Half hour after clearing of fog.
3120	Thick fog.
280	Clear region just beyond fog.
1550	Region farther out of fog.

Near the island of Crete, and within the belt of fog surrounding it, the dustiness was 2500, while as the outer limit of haze was neared, the number of particles per cc. fell to 1125.

Further examples yet of the manner in which the atmosphere may be cleansed of dust by natural means are at hand in the experiments on the Riffelberg, where comparison of the values recorded on July 4th, 6th, and 7th shows a gradual diminution in the amount of dust after sleet and rain on the nights of the 5th and 6th, whereas there had been no rain for four days previously to July 4th.

As to the precise nature of the dust found over the ocean, little more can be said but that there seems to be some reason for supposing it largely to consist of particles of salt produced by the evaporation of sea water from fine spray. How largely the air may become charged with dust of this kind at the sea margin, even when there is little more than a ripple breaking on the shore, has been shown by Mr. Aitken's experiments at Ballantrae, and one would naturally suppose that this manufacture of dust also goes on at sea whenever spray formation takes place there. Now we know that rain in falling washes out more or less of the dusty impurities of the air, and if, therefore, sea air be largely charged with particles of salt, one would expect to find the amount of chlorine in ocean rain large as compared with that in rain which falls on inland districts.

I have been unable to find any analyses of rain water collected on the ocean, but on comparing those made in the London Basin, and on the west and extreme south-west coast of England, it appears that whereas in the London rain water the amount of chlorine (chiefly in combination with sodium) is 0·12 per 100,000 parts, the proportion in rain falling on the west coast[1] is 5·46, and in some collected from "the landward roof of the Land's End Hotel" it has been found to be 21·8.[2]

It is just possible that a small part of the chlorine which exists in coast rain may be due to the washing out by it from the air of spray particles generated by waves beating on the shore near the place of observation. But at the time when the tests were made on the Pacific and Indian Oceans, almost continuous fine weather with smooth sea prevailed. This was especially the case in the latter region, where for some days the sea was completely calm. The dust observations, moreover, when any wind at all was blowing, were taken upon the windward side of the vessel at the bow, so that the spray produced by the motion of the ship could not interfere with the results.

Hence, if sea-dust consist in great measure of salt particles, these must be of such extreme fineness as to remain suspended in the air, even in calm weather, for many days after their formation. There are certainly

[1] *Water Supply of England and Wales.* (E. de Rance.)
[2] *Sixth Report of Rivers Commission.*

two points in connection with these ocean observations which might in this manner be partially explained: firstly, the fact that while the average dustiness on the Indian Ocean was 512, 613 is the corresponding value for the Pacific, where the weather on the whole was not quite so calm, and the waves were seen at times tipped with streamers of spray; and secondly, that on the Atlantic, where external conditions were still more variable, we find a greater irregularity in the results and the considerably larger average of 2053 for the number of grains of dust per cc. It seems hardly possible, however, that sea-dust should consist of salt entirely, and since it is very improbable that it contains any appreciable amount of organic matter, one is led to speculate as to whether the remaining part may not be accounted for by supposing it to be partly of meteoric and partly of volcanic origin. In support of this last conclusion, attention may be called to Experiment 29 below, where the high value of 9470 particles per cc. is recorded from tests taken on the shore of Lake Taupo, New Zealand, and in the direct line of the smoky air blowing from the active Ngauruhoe more than fifty miles away.

It is interesting to note here that the Atlantic observations, indicating the existence of rather larger quantities of dust than one would have expected, were made during what appears from the *North Atlantic Pilot Charts* for 1894 to have been the period of maximum fog for that year.

Dust and Transparency.

Passing on to some of the effects produced by dust in our atmosphere, and considering firstly the part played by it in relation to the transparency of the air, it is only necessary to indicate here how far these results below point to conclusions with regard to "Alpine haze," similar to those arrived at by Mr. Aitken as the outcome of his far completer work in this domain.

All the Swiss observations were made when there was more or less of the bluish "Alpine haze," with the exception perhaps of one set, No. 48 on the Riffelalp, where, side by side with a low value for the amount of dust per cc., was an extreme clearness of air noticed not only by myself, but by other independent and quite disinterested observers.

The accompanying table shows the amount of dust found upon certain occasions, together with the state of the atmosphere at the time.

Date.	No. of particles per cc.	Condition of air.
June 18	2130	Extremely thin bluish haze.
„ 19	3843	Much about the same.
„ 27	1666	Faint blue haze.
July 2	875	Air clear after a day's rain.
„ 7	1130	Air very clear.
„ 8	3375	Air not so clear.
„	2750	Air distinctly hazy.
„ 13	263	Air much clearer than on any previous occasion.

The relation appears to be of this nature, that whereas when the air seemed unusually free from haze, there was but little dust in it, at other times of less transparency, though there might be some rough proportionality between the dustiness and amount of haze, it was by no means

found that an increased haze effect always corresponded to a larger amount of dust. This points to the importance of another factor in haze formation, which the experiments of Mr. Aitken have proved to consist in the water coating of the nuclei.

The value of the results quoted below is much lessened by absence of any information as to the hygrometric state of the air, which it was impossible to obtain; but I can hardly doubt that had a record been made of humidity, together with that of the amount of dust on these occasions, that this high "Alpine haze" would have proved different from that of lower regions, to which the work of Mr. Aitken specially relates, only in the size of its particles, and to consist like it of nuclei of dust covered with a variable amount of water.

In close connection with these dust observations are a few facts which it has been thought worth while to bring together here, as perhaps throwing some little additional light upon those absorption phenomena exhibited by our atmosphere in relation to solar radiation, *i.e.* the blue colour of the sky, the ultra-violet absorption in the spectrum of the sun, and the possible influence of the dust in the atmosphere upon its diathermancy.

(1) "Alpine haze" is of a faint sky-blue colour, and probably consists of particles of dust with a small amount of water condensed upon them.

(2) The air resting over the ocean has proved to be very pure upon all occasions when observations have been made, and there is some reason for supposing that the amount of dust per cc. diminishes with increase of height above the surface, as is found to be the case in mountain regions, so that the body of air through which the sun's rays travel to us here at rising and setting is relatively very free from dust; and in harmony with this it was observed on the Pacific and Indian Oceans that there was a marked absence of red and orange colour effects at sunset.

(3) One of the only two evenings on which any noticeably brilliant colour effects were remarked during a period of two and a half months in New Zealand, was that previous to the morning of the 6th of December, when the air was found to be very largely charged with nuclei, and the dustiness was fifteen times greater than its average value on the Pacific.

(4) Langley has shown by experiments on Mount Whitney that the lower layers of the atmosphere absorb the blue rays from the direct light of the sun much more rapidly than do the upper (and less dusty) strata.

It seems not unlikely that the reason why sunburn, an effect like that produced by exposure to a naked arc light, probably due to the influence of radiation of short wave length upon the skin, is more readily acquired on mountains than in the lowlands, is to be found in the relatively small dustiness of the air in the former of these regions.

With regard to the rapid absorption of the ultra-violet region of the solar spectrum, the suggestion that it might possibly be due to a lateral scattering of waves of small length by foreign matter floating in the air was made for the first time, I believe, by Lord Rayleigh in 1871. In a paper in the *Philosophical Magazine* of that year, he says (referring to the

scattering of light by small particles): "I cannot but think that this rapid diversion of the rays of short wave length has a good deal to do with the absence of light of the highest refrangibility from the direct rays of the sun."

But in the summer of 1879 a series of experiments on the limit of the sun's spectrum in the ultra-violet was made in Switzerland by Cornu,[1] from the results of which he concluded that (for reasons given below) this effect could not be attributed, save in very small measure, to the action of atmospheric dust. Now I would venture to show that in order to arrive at this conclusion, an assumption was made with regard to the distribution of dust which recent experiment seems to render inadmissible, and that in consequence M. Cornu's objection to dust as a possible cause of more than a very small part of the absorption phenomenon in question ceases to be valid.

Without entering here into details, it need only be said that M. Cornu found, as the result of his observations, that the minimum wave length visible in the ultra-violet region increased by 1 mm. for an increase of altitude of 868 metres, and that in the theoretical consideration of his results he arrived at certain formulæ, from which by combining his own data with those relative to the distribution of various absorbing substances in the atmosphere it was possible to calculate roughly what change of level would be necessary in these supposed cases to bring about the observed variation of 1 mm. With regard to atmospheric dust as a cause of the phenomenon in question, he says: "We know besides that dust occurs especially in the lower layers of the atmosphere, disappearing almost completely at high levels." And again: "One can form some idea of the distribution by supposing, for example, that at an altitude of 1000 metres there only exists $\frac{1}{10}$th part of the amount of dust which obscures the lower regions of the atmosphere." On this assumption, the change of level necessary to produce the 1 mm. variation of wave length comes out to be 48·8 m., making the absorption 20 times more rapid than it was actually observed to be, from which the conclusion is drawn that atmospheric dust plays but a secondary part in the absorption of ultra-violet radiation—a conclusion expressed with less reservation by M. Mascart in his recent *Traité d'Optique* in the following words:—"Il résulte de là que (la vapeur d'eau et) la *poussière* n'interviennent pas ici, puisqu'elles sont surtout limitées aux couches inférieures, et donneraient lieu à une variation de visibilité bien plus rapide."

Now it may be shown that if we suppose the effect in question to be *wholly* due to the action of dust, the required difference of level of 868 metres for the 1 mm. change in minimum visible wave length would be given by supposing the dustiness of the air within the limiting altitudes between which M. Cornu's observations were made, to become less in the ratio of 8·8 to 10 for a rise of 1000 metres.

We shall then consider the respective merits of these two alternatives — firstly, the ratio $\frac{1}{10}$ assumed by M. Cornu, which gives the relative amounts of dust at the stations under consideration as follows:—

Riffelberg.	Rigi.	Viège.
1	10	100

[1] *Comptes Rendus*, vol. lxxxix. p. 808.

secondly, the ratio 8·8 to 10 (required by theory if the whole effect be due to dust) bringing the relative amounts thus:—

Riffelberg.	Rigi.	Viège.
7·7	8·8	10

In examining what evidence is to be gathered from dust observations as to which of these two alternatives more nearly represents the state of affairs at the time of M. Cornu's experiments we shall, in the first place, consider briefly the actual amounts of dust at these places, which would probably be entailed by the two assumptions respectively; and, secondly, what is the average value of this ratio per 1000 metres indicated by some of the results tabulated at the end of this paper.

It appears from a footnote to M. Cornu's paper that his research was carried on at the end of July during one of those weeks of fine weather with cloudless sky and Northerly winds, so often occurring after an unsettled period at this time of year in the district under consideration. Now the dust observations on the Riffelberg were made at a point not very far removed from that where M. Cornu worked, in weather of practically the same character, and within three weeks of the same time of year. At Viège, on the other hand, no dust observations have as yet been carried out, but those of Mr. Aitken on the Rigi, though unfortunately for our present purpose made rather early in the year, and therefore rather less valuable as evidence in this matter than they might otherwise have been, are still of much significance.

The average dustiness on the Riffelalp in July 1895, apart from local pollution, was 1522, and assuming this to be not very different from its value under practically the same conditions in July 1879, we find the actual amounts of dust at the observing stations, according to M. Cornu's ratio, to be as follows:—

Riffelberg.	Rigi.	Viège.
1522	15,200	152,000

Now the highest value yet recorded on the Rigi is 16,500, an exceptional amount of dust probably due, as Mr. Aitken remarks, to the wind having blown for some time previously from a very impure region. Again the average of all Mr. Aitken's observations between 1890 and 1893, when the wind on the Rigi was Northerly, that is from inhabited and therefore polluted areas, is 5755, and it appears that only in three places—Edinburgh, Paris, and London—have higher values than 150,000 particles per cc. ever been obtained in the open air.

Even supposing that at the time when M. Cornu's experiments were in progress on the Riffelberg, the average dustiness there for three consecutive days was but a third of its value in July 1895, we still have the high number of 50,000 nuclei per cc. to account for in the neighbourhood of Viège.

Turning now to the value of the ratio per 1000 metres derived from some of the tests below (Experiments 50, 51, etc.), we see that none of them imply nearly so rapid a variation of dustiness with altitude as is involved in M. Cornu's assumption. Their average is about $\frac{1}{4}$, a ratio

giving the relative amounts of dust at the different stations as follows :—

Riffelberg.	Rigi.	Viège.
6·4	8	10

And the actual amounts—

1522	1902	2378

If, moreover, the value $\frac{4}{5}$ be introduced into M. Cornu's equations in lieu of his assumed ratio $\frac{1}{10}$, the change of level necessary to produce the 1 mm. variation in minimum visible wave length comes out to be 520 metres.

We therefore conclude from these considerations that though it is impossible to say what was actually the value of this ratio in question at the time of M. Cornu's experiments, it probably lay considerably nearer to that of $\frac{8 \cdot 8}{10}$ required by theory, than to that of $\frac{1}{10}$ which M. Cornu assumed, and that we are therefore still at liberty to regard the absence of ultra-violet light from the direct rays of the sun as due in no small measure to the action of atmospheric dust.

Lastly, I would call attention to one more result brought to light by S. P. Langley's work on Mount Whitney ; namely, that the lower layers of the atmosphere in this region appeared to transmit the rays of long wave length as readily as the higher strata, from which it would seem likely that the dust in the atmosphere of sparsely inhabited areas, at least when it is coated with but a small amount of water, exercises comparatively little influence on the diathermancy of the air.

ATMOSPHERIC DUST OBSERVATIONS.

Group I.

	Number of Nuclei per cubic centimetre.
EXPERIMENT 1. *July* 17, 1894.—Atlantic, 55° 0′ N., 42° 11′ W., 10.30–12.30. Temperature 46°. This result is the average from a large number of tests.	2000.
Ex. 2. *July* 18.—Atlantic, 2.0–4.0 p.m. Sky clear blue ; weather fine ; rain in early part of day ; wind light W. Average of several tests. Temp. 42°.	4000.
Ex. 3. *July* 19.—Atlantic, 10.0–11.0 a.m. Thick fog ; very little wind. Temp. 44°.	3000.
Ex. 4. *July* 20.—Between Labrador and Newfoundland, 2.30–3.30 p.m. Vessel sailing at about 15 miles per hour. Sky overcast, uniform grey ; wind light W.; foggy all morning, clear at time of experiments. Temp. 49°.	420, 700, 420, 840, 420, 560, 700, 840, 560, 420, 560, 560, 420, 840.
Ex. 5. *July* 21.—Gulf of St. Lawrence, 11.0–12.0 a.m.	
(*a*) Thick fog.	3500, 2000, 2000, 5000.
(*b*) Fog just clearing.	280, 280, 280.
Observations taken again after lapse of few minutes. (*c*) Fog quite cleared.	2500.
(*d*) Few minutes later.	1500, 1625, 1750, 1375, [1625.
Summary.—Fog average, 3120 ; clearing average, 200; beyond fog, 1575. Temp. 60°.	
Ex. 6. *Sept.* 19.—Belmont, Vancouver Island. Afternoon. This was first set taken after the receiver had been cleaned and relined. Counter not working quite satisfactorily ; possibly some error due to impact of "stirrer" on wall of receiver.	1750, 1625, 1750, 1625, 1500.

GROUP I.—*Continued.*	Number of Nuclei per cubic centimetre.
Ex. 7. *Sept.* 21.—Oak Bay, Victoria, V. I., at a point on the shore about 3 miles from Victoria, and about ¼ mile from nearest building. Sky clear blue; wind fresh from land. No error due to "stirrer."	1000, 1000, 1250, 1000, 1000, 1250, 1000, 1125.
Ex. 8. *Sept.* 22.—Straits of St. Juan de Fuca, on board steamer, 11.45 a.m. Sky cloudless; air clear; wind light S.E. off land. Distance from Victoria about 18 miles.	1875, 2000, 1875, 2000, 2000, 2000.
Ex. 9. *Oct.* 6.—Santa Cruz, Cal., on spit of rock running out into sea about 80 yards from shore. Noon. Sky overcast; air slightly foggy; wind very light, from sea.	1500, 1500, 1500.
Ex. 10. *Oct.* 7.—Santa Cruz Bay, Cal. Noon. Six experiments gave nearly same result. Sky overcast; air far less hazy than yesterday; wind slight, off sea. Air had been foggy nearly all previous day.	700.
Ex. 11. *Oct.* 8.—Santa Cruz Bay, Cal., 11.30–12.30. Large amount of blue sky; air pretty clear, though not quite so much so as yesterday; wind fresh S.W. off water. There had been a light fog blowing over from sea all morning until about 11.30, when it cleared.	1250, 1000, 1000, 1000, 875, 750, 1000, 1000, 1000, 1000, 1000.
Ex. 12. *Oct.* 9.—Santa Cruz Bay, Cal., 10.30–11.0 a.m. Air fairly clear to windward, though not quite so much so as yesterday; light fog masses rather above the sea-level passing over land at intervals; wind light S.W. from sea. Whole place as usual wrapped in fog earlier this morning.	1000, 1000, 1000, 1125, 1060, 1000.
Ex. 13. *Oct.* 9.—San Lorenzo Valley, about 6 miles inland. Afternoon. Weather fine, sunny. Experiments made on sloping bank of the river. We see that the amount of dust per cc. of air here is roughly double what it was at seaside this morning.	2250, 2500, 2000, 2000, 2000, 2000, 2250, 2000, 1750.
Ex. 14. *Oct.* 11.—Santa Cruz Bay, Cal., 11.30–12.15. Sky cloudless; air in neighbourhood clear, but Santa Cruz mountains 13 miles away just hidden. Wind light E., right off land. After noon long horizontal bands of light smoke-coloured haze were noticed hanging over the mountains from Santa Cruz southwards towards Monterey. Morning fog cleared off earlier than usual. *N.B.*—All these Santa Cruz experiments, with the exception of the first set, were made at same spot, 1½ miles from the town, and on a wall of rock running out some yards into the sea.	4500, 4500, 4000, 4000, 4000, 4500.
Ex. 15. *Oct.* 24.—Pacific Ocean, 24° 51′ N., 152° 40′ W., 9.30–10.15 a.m. Sky overcast with small percentage blue sky; air clear. In all these and following experiments care was taken to avoid artificial pollution from air blowing over vessel. They were all made on windward side of vessel on "bridge." Vessel making about 12 miles per hour.	560, 560, 560, 490, 560, 523.
Ex. 16. *Oct.* 25.—Pacific Ocean, 21° 55′ N., 156° 40′ W., 9.30–10.15 a.m. Sky overcast, weather showery.	350, 280, 315, 350, 280, 350, 280.
Ex. 17. *Oct.* 27.—Pacific, 14° 8′ N., 161° 3′ W. Morning. No mention made in notebook of external conditions.	1250, 1000, 1000, 1125, 1000, 1000.
Ex. 18. *Oct.* 30.—Pacific, 0° 8′ N., 166° 14′ W. Morning. Temp. 81°. It is inadvisable, when working, to have more than 5 or less than 2 drops per square mm. Therefore only the limits between which number of particles lies can be given in this case. More than 2 on 1 square mm. with ¼ impure air, and less than 5 on 1 with receiver full of air. Sky nearly cloudless. Air clear; wind E.S.E.	700–1000.

	Group I.—*Continued.*	Number of Nuclei per cubic centimetre.
Ex. 19.	*Oct.* 31.—Pacific, 4° 52′ S., 168° 3′ W. Noon. Small percentage high white cumulus cloud ; air clear ; wind E. Temp. 82°.	630, 770, 700, 665, 700, 735.
Ex. 20.	*Nov.* 1.—Pacific, 9° 50′ S., 169° 53′ W. Noon. External conditions practically same as yesterday. Wind slightly shifted to N. Temp. 84°.	735, 525, 490, 630, 490, 490, 700
Ex. 21.	*Nov.* 3.—Pacific, 17° 57′ S., 172° 38′ W., 12.0–12.40 p.m. Sky clear blue ; small percentage cloud ; air clear ; wind light S.E. Temp. 81°.	455, 455, 375, 420, 350, 375.
Ex. 22.	*Nov.* 4.—Pacific, 12.15–12.40 p.m. Sky cloudy ; cirro-stratus and nimbus ; wind moderate E. Four tests gave nearly same value. Temp. 76°·5.	245.
Ex. 23.	*Nov.* 5.—Pacific, 27° 27′ S., 178° 3′ W., 12.15–12·40 p.m. Sky cloudy, cirro-stratus and cumulus ; air clear ; wind S.E. Trade. Temp. 74°.	420, 490, 515, 490.
Ex. 24.	*Nov.* 7.—Pacific, 31° 51′ S., 178° 46′ E., about 358 miles from Auckland, 11.45–12.10 p.m. Sky overcast ; air clear ; wind S.S.W. Temp. 72°.	1250, 1250, 1375, 1125, 1125, 1250.
Ex. 25.	*Nov.* 8.—Pacific, 10 to 15 miles from Great Barrier Island, 10.0–10.20 a.m. Sky cloudless ; air clear ; wind S. to S.W. Temp. 70°.	2125, 1625, 1625, 2000, 2125, 1625.
Ex. 26.	*Nov.* 26.—Wairakei, New Zealand, North Island. These first New Zealand experiments made in a geyser valley, and on top of its bounding hills were only preliminary trials. They indicated a value for amount of dust per cc. about 1000, but a regular series of observations was not made.	
Ex. 27.	*Nov.* 27.—Huka Falls, Wairakei, N. Z., 11.0–11.30 a.m. Sky rather cloudy ; air clear ; wind S.W.	1000, 937, 875, 1125, 875.
Ex. 28.	*Nov.* 28.—Rapids of Waikato River, N. Z., North Island, 12.0–12.15 p.m. Conditions much the same as yesterday. Sky moderately cloudy ; air clear ; wind S.W.	1000, 875, 1000.
Ex. 29.	*Dec.* 6.—N.E. shore of Lake Taupo, N. Z., North Island. Noon. Some clouds ; large percentage blue sky ; long line of cloud over crater of Ngauruhoe ; wind light, blowing almost directly from the volcano 55 miles away. Large amount of dust probably due to stream of smoke from the active crater.	10,320, 8750, 9500, 8000, 10,250, 10,000.
Ex. 30.	*Dec.* 7.—Lake Taupo, same position on shore, 11.0 a.m. Much rain has fallen since yesterday ; sky quite overcast ; air very hazy — an island 14 miles away just visible ; wind variable about N.E. First two results were obtained with $\frac{1}{10}$th and last three with $\frac{1}{4}$th of impure air. Wide difference between figures of the two sets seems to point to either leakage (?) or pollution.	2000, 1850, 1250, 1125, 1125.
Ex. 31.	*Dec.* 9.—Lake Taupo, south shore. Observations taken two miles from Tokaanu, outside a Maori Settlement. Wind E.	1750, 1750, 1375, 1500.
Ex. 32.	*Jan.* 1, 1895.—Near Glenorchy, Lake Wakatipu, N. Z., South Island. Experiments of this morning of very little value, but appear to indicate value between 500 and 1000 for amount of dust per cc.	
Ex. 33.	*Feb.* 16. King George's Sound, Australia. Observations made on board vessel lying at anchor ; 12.15–12.40 p.m. Sky cloudy ; air clear ; wind S.	1250, 1125, 1250, 1000, 1000.
Ex. 34.	*Feb.* 20.—Indian Ocean. Several experiments made from 9.45–10.30 a.m. gave number of particles per cc. somewhere between 150 and 200 ; but as there were always less than 2 drops per sq. mm. of counting plate individual figures are not given. Accurate results may be still obtained by counting drops on 9 or more squares. Sky overcast ; air clear ; wind light, S.W. to S.S.W.	

	Group I.—*Continued.*	Number of Nuclei per cubic centimetre.
Ex. 35.	*Feb.* 21.—Indian Ocean, 14° 16′ S., 96° 24′ E., 11.0–11.30 a.m. Space traversed during experiments about 8 miles. Sky overcast; air clear; wind about N.W.	490, 490, 305, 420, 305, 280, 350.
Ex. 36.	*Feb.* 22.—Indian Ocean, 9° 38′ S., 92° 18′ E., 10.30 a.m., and again at 11.0 a.m. Last two observations *after a shower*. Sky very slightly cloudy; air clear; wind very light N.W.	313, 350, 280, 280
Ex. 37.	*Feb.* 23.—Indian Ocean, 4° 57′ S., 88° 52′ E., 11.0–11.15 a.m. Sky almost cloudless; air clear; wind N.W.	280, 243, 313, 280
Ex. 38.	*Feb.* 24.—Indian Ocean, 0° 21′ S., 85° 19′ E., 11 a.m. Several experiments made after much rain had fallen, gave number per cc. from 173–243. Sky cloudy; air clear.	
Ex. 39.	*Feb.* 25.—Indian Ocean, 4° 10′ N., 81° 48′ E., 12.30 p.m. Sky overcast; air clear; wind N.E. Monsoon (from Bay of Bengal).	420, 630, 453, 420
Ex. 40.	*Mar.* 3.—Indian Ocean, 9° 30′ N., 64° 15′ E., 11.0–11.15 a.m. Slight amount of cumulus cloud; air clear; wind N.N.E. to N.E.	1000, 1125, 1250, 1000
Ex. 41.	*Mar.* 4.—Arabian Sea, 10° 34′ N., 58° 56′ E., 10.0–10.30 a.m. Small percentage cumulus cloud; air clear; wind N.E.	1375, 1125, 1125, 1250, 1000
Ex. 42.	*Mar.* 5.—Arabian Sea, 12° 0′ N., 52° 30′ E., 5.20–5.40 p.m. Sky cloudless; air clear; wind N.N.E.	280, 420, 313, 420
Ex. 43.	*Mar.* 9.—Red Sea, 10.30–10.50 a.m. Sky clear; small percentage cumulus cloud; air very slightly hazy; wind N.N.W.	490, 383, 453, 490
Ex. 44.	*Mar.* 14.—Mediterranean Sea, 10.5–10.30 a.m. Vessel just passing the eastern end of Crete, 3 or 4 miles from land. Sky cloudless; air hazy; wind variable N.W. by W. to W. Figures show gradual diminution of dust as fog region round island was traversed.	2500, 2500, 2000, 1750, 1125
Ex. 45.	*Mar.* 16.—Mediterranean, 36° 29′ N., 15° 7′ E., 11.40–12.0 a.m. Sky overcast, cumulus and nimbus clouds; air pretty clear; wind S.E.	1250, 1125, 875, 1250, 1000

Group II.—Switzerland.

Ex. 46.	*June* 18, 1895.—Ridge of La Paraz, Diablerets, altitude 8360 ft., 3 p.m. Sky nearly cloudless; air clear with extremely thin bluish haze; wind S. La Paraz is the highest point of range forming northern wall of Vallée des Ormonts at Ormonts Dessus. The village was 4300 ft. below. Results show how polluted air was being carried up from below by S. wind.	2000, 1750, 2000, 2500
Ex. 47.	*June* 20.—Ormonts Dessus, at point outside the Commune, altitude 4000 ft., 11.30–12.0 a.m. Sky slightly cloudy; air just about as clear as on 18th; wind S.W.	2500, 2000, 2000, 2000, 1500, 1750, 2000
Ex. 48.	*June* 21.—Ormonts Dessus, same distance from Commune, altitude 4080 ft., 10.30–11.0 a.m. Weather has changed after a Föhn wind, and much rain has fallen. Sky quite overcast; clouds down in valley; air rather hazy; very little wind. Point of observation about 80 ft. above the village in spot free from clouds, but where it was raining heavily. Air probably largely polluted by smoke from the village.	3500, 4500, 4000, 4000, 3750, 4250, 3500, 3250

Group II.—*Continued.*	Number of Nuclei per cubic centimetre.
Ex. 49. *June* 22.—Col du Pillon. This lies roughly east and west, is about 3 miles east of Ormonts Dessus, and there are very few chalets in neighbourhood. Probably far less artificial pollution here than in valley below. Yesterday it was swept by clouds for many hours. Altitude 5200 ft., 11.40–12.0 a.m. Sky overcast; air slightly hazy (about same as on 21st); wind E.	2250, 2250, 2000, 1750, 2000, 2000
Ex. 50. *June* 24.—Vallée des Ormonts, on grass slope about 2000 ft. above village, and some distance from any chalets, altitude 6000 feet, 1.45–2.0 p.m. Sky overcast; raining; air very slightly hazy; wind N.	2750, 2333, 2250, 2500
Do.—2nd set, at lower point on hill, altitude 5000 ft., 3.0 p.m. No rain.	3000, 3000, 2750, 3000
Ex. 51. *June* 27.—Summit of Oldenhorn, altitude 10,250 ft., 3.0 p.m. Sky slightly cloudy; air pretty clear, with faint bluish haze as on 18th; wind light W., probably carrying up polluted air from the village 6000 ft. below.	1750, 1500, 1750
Ex. 52. *July* 2.—Riffelberg, Zermatt; noon; altitude 7400 ft. Sky rather cloudy; air clear; wind light S.W. Observations taken after a day's rain, and are not quite satisfactory owing to rapid evaporation of drops from lower plate.	875, 750, 1000
Ex. 53. *July* 4.—Riffelberg, 11.30–12 p.m.; altitude 7250 ft. Sky cloudy; air about as clear as on July 2nd; faint haze; wind light about N.W., blowing from direction of the Gabelhörner. Spot swept by clouds until about 9.0 a.m. No rain since July 1st.	2000, 2250, 2000, 2000, 1750, 2000, 2250, 2000
Ex. 54. *July* 6.—Riffelberg, 11.20–11.50 a.m.; altitude 7250 ft. Conditions made same as on July 4th. Place in clouds until 9.30 a.m. Rain and sleet during night. Air pretty clear—rather more so towards west than north. Sky cloudy; wind light N.W. Temp. 54°.	1750, 1750, 1750, 1275, 1250, 1125, 1250
Ex. 55. *July* 7.—Riffelberg, 10.50–11.15 a.m.; altitude 7250 ft. Sky nearly cloudless; air *very clear;* wind light about N.N.W. Temp. 45°. More rain and snow during night.	1125, 1125, 1250, 1187, 1125, 1125, 1000
Ex. 56. *July* 8.—Riffelberg, 10.30–11.0 a.m.; altitude 7230 ft. Sky cloudless; air not so clear as yesterday; wind gusty, N.—occasionally bringing down smoky polluted air to place of observation. No rain since yesterday. Air along Zermatt Valley towards Visp distinctly hazy. Temp. 45°.	3250, 3000, 4500, 3000, 4000, 3750, 3000, 3750, 2500, 3000
Ex. 57. *July* (?).—Riffelberg, 11.30–11.50 a.m.; altitude 7400 ft. Experiments made at same place as on July 2nd. Sky overhead clear; air towards north quite hazy; clear below about Zermatt, but distinctly hazy above valley towards Oberland. Wind light N. Clouds on Oberland Peaks, and from Weisshorn to Gabelhorn.	3000, 2750, 2500, 2500, 3000
Ex. 58. *July* 13.—Riffelberg, 10.20–10.50 a.m.; altitude 7250 ft. Some high clouds. Wind strong gusty N.W. *Air extremely clear;* this was remarked by many other persons, and it was clearer than I have ever previously seen it. Temp. 50° Since yesterday evening wind has veered from S.W. to N.W., and rain and snow have fallen. Place of observation swept by clouds until 10.0 a.m. Results from 4th to 9th show pollution. Disturbance afterwards found to arise from smoke from a chalet some 1000 ft. below point where experiments were made.	250, 287, 250, 700, 875, 1000, 625, 575, 225, 425, 625

GROUP II.—*Continued.* — Number of Nuclei per cubic centimetre.

Ex. 59. *July* 22.—Riederalp. Experiments made in the clouds at a point on the Riederalp, some 200 yards from the hotel, and not in the stream of polluted air from latter. Clouds had been drifting over the alp since 6 a.m. At time of maximum opacity of air a chalet about 55 yards away was just rendered invisible. No sky visible; air probably saturated with moisture; wind very light S.W., 10.0–11.45 a.m.; altitude 6315 ft.

State of Atmosphere.	Clear area in Clouds.	Rather thicker.	Thicker, raining.	Ditto.	Ditto.
Amount of Dust per cc.	560	560	595	490	560

State of Atmosphere.	Still thicker, raining.	Thicker and raining.	Still thicker, less rain.	Maximum density, less rain.
Amount of Dust per cc.	665	700	805	1225

Rather thinner, less rain, 560; locally almost clear, no rain, 455.

Ex. 60. *Aug.* 9.—Arolla, western fork of Val d'Hérens, 4.0 p.m.; altitude 6500 ft. Experiments made after week of unsettled rainy weather. Sky rather cloudy; air clear with faint blue haze. — 1375, 1500, 1625, 1500

Ex. 61. *Aug.* 24.—Combasana, above Zinal, Val d'Anniviers. Experiments made at three different levels under practically invariable conditions. Air clear, faint blue haze; sky slightly cloudy; wind gusty S.

	Combasana, altitude 8500 ft., 2.0–2.15 p.m.	Roc de la Vache, 8200 ft., 3.40 p.m.	Alp de Tracuit, 6700 ft., 5.10 p.m.
Amount of Dust.	1500, 1250, 1250, 1000	525, 513, 465, 420	1000, 1000, 750, 1000, 1000

At the last station sky was rather cloudy; air rather hazy; thicker towards Rhone Valley. Practically no wind.

Ex. 62. *Sept.* 4.—*Summit of Bieshorn*, 10.20–10.40 a.m. Altitude 13600 ft. Temp. 35°·6. Sky cloudless; air clear, with faint blue haze, which appeared thickest towards north. Below, and some miles to west, very few small cumulus clouds. Towards north, apparently stretching from north-east to north-west, a band of grey haze, of nearly uniform height throughout its length. Wind very light S. — 140, 140, 175, 175

Bieshorn, lower point, 11.20 a.m. Altitude 13,200 feet. Conditions nearly same; no wind. — 175, 211, 211, 280

Bieshorn, east of snowfield on Turtmann Glacier. Conditions same; no wind. Clouds mentioned above slightly increased. Noon. Altitude 11,000 feet. — 245, 315, 210

Col de Tracuit, 1.30–2.0 p.m. Altitude 10,665 ft. Air same; wind S., gusty, moderate blowing over level area east of Roc de la Vache. Clouds larger and more numerous. Temp. 50°·5. — 420, 420, 490, 280 (?), 420

East of Roc de la Vache, 3.0 p.m. Altitude 8400 ft. Air quite clear; mountains on other side of Rhone Valley quite distinct; faint blue haze visible even across Zinal Valley. Wind S. and gusty. — 385, 630, 595, 490, 420, 560

These experiments were all made upon the summit of the Bieshorn, and at various points on the return journey from it. The simplicity of its ascent and its height made it a very suitable mountain for observations. It forms part of the chain containing the Rothhorn and Weisshorn, rising about 9000 ft. above the Zermatt Valley, and

some 8000 ft. above that of Zinal. Northwards, and some 2500 ft. below its summit, lies a "covered" glacier, while in a south-westerly direction stretches a region many miles in extent of snow-capped peaks of glaciers.

Summary of Results.

Altitude above Sea Level	13,600 ft.	13,200 ft.	11,000 ft.	10,665 ft.	8,400 ft.
Average Amount of Dust per cc.	157	219	257	406	513

The large difference between the third and fourth results at places not very different in level can be explained by the configuration of the mountain at the two regions.

DISCUSSION.

The President (Mr. E. Mawley) considered this one of the most interesting papers that had been submitted to the Society for some time, and that the observations made by Mr. Fridlander with his little dust counter in different parts of the world were deserving of careful examination and consideration. There occurred one remark in the paper which was contrary to his own experience, and that was where he stated that there was an absence of red and orange colour effects in the sunsets of the Indian Ocean. For when becalmed some years ago in the South Indian Ocean the sunsets evening after evening were the most magnificent and varied in colouring that he had ever seen. This was the first time that the subject of atmospheric dust had been brought before the Society, and their thanks were due to the author for the trouble he had taken in making the observations, and also for the clear and interesting way in which they had been arranged and discussed.

Mr. M. Jackson said that the more dust there was in the atmosphere the more luminous and highly coloured it became. He had often noticed in Alpine districts how easy it was to be greatly deceived by distances. From Chamounix to Mont Blanc seemed but little farther than from Fort William to Ben Nevis. This he supposed was partly due to less dust particles in the atmosphere. He should like to know the effect of snow in clearing the air of these nuclei.

Mr. F. J. Brodie said that in view of the absorbing interest of such inquiries it was rather surprising that the subject of atmospheric dust had not hitherto been brought prominently before the Society. In looking over the observations he was much struck with the large discrepancies in the number of dust particles recorded at very short intervals of time—a point he had previously noticed in reading Mr. Aitken's memoirs on the subject. Notable examples in the present paper were shown in Experiments 4, 11, and 42, all of which were taken at sea, where large fluctuations would scarcely be expected. In experiment No. 4 the number of dust particles, as shown by observations taken at intervals of five minutes or so, was on several occasions exactly twice as large as on others. He was inclined to wonder whether these large differences might not be due either to imperfections in the instrument itself or to defects in the method of observing.

Mr. R. H. Scott said that with reference to the mention made by Mr. Fridlander in his paper of his difficulty in finding records of analysis of rain in these islands, he wished to state that in *Air and Rain*, by Dr. Angus Smith, published in 1872, no less than 200 pages were devoted to the subject. The experiments on air washing in the neighbourhood of large towns often showed the presence of flakes of oxide of iron. London rain contained sal ammoniac.

Dr. C. T. Williams said there was no doubt that the paper was extremely interesting and valuable so far as it went, but the question naturally arose as to what the particles were composed of. Of course on the seaboard one would expect them to be of a saline nature, but in a mountainous district the composition must be entirely different. Then again no information was given in the

paper as to the origin of the nuclei. He should imagine that the direction and force of the wind would in some way account for the rapid changes in the number of particles at any one place. With regard to the absence of orange and red colours as mentioned by Mr. Fridlander, he (Dr. Williams) had witnessed some most magnificent sunsets on the Pacific Ocean in which these were the dominant colours. He should like to know if the instrument in use could be thoroughly relied on.

Mr. G. J. SYMONS said that Mr. G. Dines's hygrometric observations showed that the air was usually badly mixed, and if the streams in it were distinguishable to the eye many persons would be much astonished. Saline deposits had been found 50 or 60 miles inland.

Mr. R. INWARDS thought that if there was any doubt as to the efficacy of the instrument it could easily be tested by taking a cubic centimetre of air with a known number of particles, or by repeated tests of air taken from a closed vessel, when it would easily be seen if the instrument gave uniform results.

Major H. E. RAWSON called attention to the large amount of dust found to be suspended at high altitudes during a season which was recorded as being very hot and dry. In 1893 there was an extraordinarily large amount of rainfall on the summit of Ben Nevis, and a very small amount at the base, the year being a particularly dry and hot one. He thought perhaps the explanation in both cases was that the superheated surface of the ground created an up-draught, which in one case carried up the dust particles to high altitudes, and in the other the moisture of lower levels, leading to an excess of precipitation on the top of the mountain.

Mr. W. MARRIOTT said that when he visited the Ben Nevis Observatory in 1893 he saw some observations made with the large dust counter, and was much interested in them. The number of dust particles in each cubic centimetre often varied very considerably; the highest value obtained was 14,400 in April 1891, while on more than one occasion no dust particles at all had been observed. It is considered that any number over 4000 was phenomenally large, and any number less than 100 was phenomenally small. The greatest amount of dust occurs when the wind is from the South or East, and low dust values are obtained when the wind is between North-west and North-east. There is a well-marked diurnal variation in the number of dust particles, as will be seen from the following means for the three months, March to May 1891:—

1 a.m.	4 a.m.	7 a.m.	10 a.m.	1 p.m.	4 p.m.	7 p.m.	10 p.m.	Mean.
736	526	570	551	950	1438	1035	1029	854

The minimum dust values occur in the early morning when the wind force is strongest, and the maximum in the afternoon when the wind force is at a minimum.

Mr. E. D. FRIDLANDER, in reply, said that with regard to the colour effects upon the Indian Ocean, he had only made a very small number of observations, so he could not speak very decidedly upon the subject. That in order to do this it would be necessary to make many tests in the same region under varying conditions of colour. Probably it would be found that at times when these effects were much more marked the dustiness of the atmosphere was greater. The chief source of error in the instrument used was leakage, but the process of rendering the air in the receiver "dust-free" preparatory to making a test could not be carried out if any leak occurred, as the dust entering with the air prevented one from reaching the stage at which no shower of drops was formed on expansion. Observations were rejected unless the distribution of drops on the counting plate was tolerably uniform. So far as he knew no observations had yet been made on the possible purifying effects of snow with respect to atmospheric

dust. With reference to the large differences between the results obtained at times, separated only by short intervals (two or three minutes), he was not prepared to account for them, except partially by the irregular manner in which dust is produced and distributed. He did not think them due to errors of observation.

Captain D. Wilson-Barker, who was unable to attend, wrote that he thought the value of the dust particle observations taken at sea, and so close to the vessel, could not in any way represent the true state of affairs. He was prepared to admit the presence of fine salt particles in the air, which in a storm extended to a considerable height; but he did not think for one moment that these particles of salt extended to the lower level of clouds, or even in any way affected the production of fog. He had never seen even volcanic dust at sea; and while there was little doubt but that it is to be found there at times, he was of the opinion that the minute seaweed *Trichodesmum Ehrenbergii*, which covered the sea for miles and looked like coal dust, and which he had found in all the oceans, was often taken for dust particles and reported as such.

Analysis of the Greenwich Rainfall Records from 1879 to 1890, with Special Reference to the Declination of the Sun and Moon.

By MAJOR H. E. RAWSON, R.E., F.R.Met.Soc.

[Read April 15, 1896.]

Recently I had the honour to read before the Society a paper analysing the Greenwich Barometrical Records from 1879 to 1890, with special reference to the declination of the sun and moon.[1] It was found that during those periods of a lunation when the moon was south of our equator, that is, when its declination was south, the mean height of the barometer at Greenwich was higher than when the moon was north in 10 years out of the 12. The exceptions were the years 1879 and 1890. Also that when the sun and moon were both south, the mean height of the barometer was higher than when both were north in 10 years out of the 12. The exceptions were 1886 and 1890. Short as was the period examined, these results appeared sufficiently remarkable, especially when taken in connection with the novelty of the method adopted in the analysis, to warrant the expectation that equally interesting results might be obtained by investigating the Rainfall records at Greenwich for the years 1879 to 1890 in the same way.

The method of ascertaining the mean height of the barometer for the various periods was explained in the former paper. The mean of 24 hourly observations is the mean for the day. The mean for those days in each lunation in which the declination of the moon was south gave a periodic mean, from which the annual mean, moon being south, was obtained; and similarly the annual mean, moon being north, was ascertained. The days when the moon was on equator were not included. When the annual means, moon being south, were compared with the annual means, moon being north, it was found convenient to arrange the

[1] *Quarterly Journal*, vol. xxii. p. 65.

TABLE I.—RAINFALL AT GREENWICH, 1879 TO 1890, WITH SPECIAL REFERENCE TO THE DECLINATION OF THE SUN AND MOON.

Year.	1890	1879	1884	1881	1889	1883	1885	1886	1880	1888	1887	1882
MEAN DAILY :—												
(1) Moon North Declination. Ins.	0·0495	0·0693	0·0448	0·0684	0·0687	0·0514	0·0762	0·0611	0·0828	0·0758	0·0613	0·0739
(2) ,, South ,, ,,	0·0671	0·1017	0·0481	0·0737	0·0626	0·0607	0·0590	0·0736	0·0689	0·0568	0·0448	0·0607
RELATIVE RAINFALL :—												
(3) Moon North Declination.	–	–	–	–	+	–	+	–	+	+	+	+
(4) ,, South ,,	+	+	+	+	–	+	–	+	–	–	–	–
PERIODIC TOTAL :—												
(5) Moon North Declination. Ins.	9·168	12·745	7·165	12·182	12·389	8·073	12·032	9·658	14·739	15·418	11·503	12·865
(6) ,, South ,, ,,	10·335	15·891	9·513	11·877	9·968	11·050	10·627	13·330	13·087	10·203	7·441	9·582
(7) ,, in Equator. ,,	2·357	2·726	1·369	1·666	0·921	2·776	1·343	1·222	1·856	1·884	0·915	2·734
Annual Total. ,,	21·860	31·362	18·047	25·725	23·278	21·909	24·002	24·212	29·682	27·505	19·859	25·181
(8) Moon North Declination. Days.	185	184	160	178	179	157	158	158	178	177	173	174
(9) ,, South ,, ,,	154	155	179	160	159	182	180	181	161	162	166	164
(10) ,, in Equator ,,	26	26	27	27	27	26	27	26	27	27	27	27
EXCESS OF MEAN BAROMETRICAL PRESSURE :—												
(11) Moon North Declination. Ins.	0·1510	0·0353	...	...	...	...	...	...	...	...	...	...
(12) ,, South ,, ,,	...	...	0·0035	0·0118	0·0152	0·0431	0·0432	0·0523	0·0582	0·0720	0·0846	0·1003

years, not chronologically, but in an order which placed the two exceptional years, 1890 and 1879, by themselves, and the remainder in ascending order of the excess of barometrical pressure moon south over moon north. The same sequence is adopted in the table. The total rainfall for every day that the declination of the moon was north is divided by the number of days to obtain the mean daily rainfall for moon north declination (1); and the total rainfall when the moon was south, divided by the number of days, gives the mean daily rainfall for moon south declination (2). The periodic totals are given in (5), (6), and (7). In (11) and (12) are recapitulated the results obtained in the former paper from comparing the mean height of the barometer when the moon was north of the equator, with the mean height when it was south.

This table confirms in a startling manner what the barometer records already suggested. If the analysis of the 12 years 1879 to 1890 should be borne out by an examination extended over a sufficiently long period, some prognostication of the relative heights of the barometer, and of the relative rainfalls for those periods when the moon's declination is north and when the moon's declination is south, can be formed a considerable time in advance, even for such a place as Greenwich.

Look at the mean daily rainfall in (1) and (2), graphically depicted in (3) and (4), where the rainfall during the time the moon's declination is south exceeds that when the moon's declination is north in the four years on the left, 1890, 1879, 1884, and 1881; while in the four years on the right, 1880, 1888, 1887, and 1882, the opposite is the case, the rainfall with moon north exceeding the rainfall with moon south. And the order in which the years are arranged is such as to place those on the left in which the mean barometrical pressure is greater with moon north than with moon south, and those on the right in which the opposite is the case, or the mean barometric pressure is greater when the moon's declination is south than when it is north. In 1890, 9·168 in. of rainfall, in 1879, 12·745 in., when the declination of the moon is north, against 10·335 in. and 15·891 in. respectively when the declination of the moon is south, and these are the two exceptional years to the otherwise universal rule that the barometer is higher when moon is south than when moon is north. In 1887 and 1882 at the other end of the series the rainfall, as shown by (5) and (6), is much greater when the moon's declination is north than when it is south, just as the mean barometrical pressure is greater with moon south than with moon north. From (8) and (9) we see that we may fairly compare the *total* rainfall of 1890 with 1879, and of 1887 with 1882, as the moon was practically the same number of days in the same hemisphere in each of the years that are compared. It has already been pointed out that the years 1890 and 1879 resembled one another, and no other year, in the way the moon crossed the equator on much the same day and remained the same number of days in similar hemispheres. And it is remarkable that in two such different years as regards rainfall as 1890 and 1879, which differed in the annual total by no less than 9½ inches, the distribution with respect to the moon's declination should be so similar. The year 1879 was the wettest of the whole series, and is no doubt still remembered by many as an exceptionally wet year.

As regards the 4 years 1889, 1883, 1885, and 1886, in the centre

of the series, 1886 has been seen to be with 1890 an exception to the otherwise universal rule that the mean height of the barometer was higher when sun and moon were both south than when both were north. The distribution of the rainfall in 1886 is found to follow 1890, and not the years 1885 and 1880 on each side of it, and to have a smaller mean daily rainfall when the moon's declination was north than when it was south. The year 1883 was similar in this respect, and the barometrical observations for the year show that the mean height, when both sun and moon were north, was above the mean for the year, though smaller than when both sun and moon were south. The barometrical means for 1883 are, annual mean, 29·78 in.; periodic mean, sun and moon both being north, 29·81 in.; periodic mean, sun and moon both being south, 29·88 in.

When therefore we look into the figures contained in (1) and (2) and graphically depicted in (3) and (4), we see that during the 12 years 1879 to 1890 there was a distinct tendency on the part of the rainfall to follow the barometer. At the two extremes of the series where the barometer was markedly higher during one part of a lunation than during the other, the rainfall followed suit, but in the centre of the series indecision appears as shown by the alternate *plus* and *minus* signs. This is just what we would expect for Greenwich, and the remarkable thing is not that we find that the rainfall does not always follow the barometer, but that in an investigation conducted on such novel lines we find such consistent results. It encourages us to look further and to try and discover whether these 12 years, chosen at random, and for no other reason than that the observations were at the time of making the calculations the latest published from Greenwich, whether they point out any particular portion of a moon's lunation as better than the rest. Here for the first time in the investigation the judgment of the analyser has to be called into play. Hitherto no errors but arithmetical ones could creep in, but when it becomes necessary to analyse the Greenwich records of rainfall with relation to distinct periods of the moon's lunation which do not synchronise with the records, judgment must be used. Up to the present no rainfall observations that the writer is aware of have been carried out in connection with the orbit of our rather erratic satellite. Until they are, any deductions made from the rainfall during those periods of lunation when the moon is ascending from maximum south declination to 0°, and from 0° to maximum north, and is descending from maximum north to 0°, and from 0° to maximum south, must be received with reserve. These periods may be adopted for the purposes of the present analysis, and they have the advantage that during the 12 years under consideration they were found to synchronise very fairly well with the Greenwich rainfall observations, and judgment as to the distribution of any particular fall between one or other period was remarkably seldom required. At any rate, as no particular result was being looked for, any such distribution was made without partiality. The figures to be given are believed to be substantially accurate.

In Table II. are given the total rainfall of each year, which fell during each of the quadrants maximum south to 0°, 0° to maximum north, maximum north to 0°, and 0° to maximum south. As the number of days varies during the year during which the moon remains in any one quadrant, it is more accurate to compare the mean daily rainfalls in each

TABLE II.—PERIODIC RAINFALL.

Year.	Moon Ascending.				Moon Descending.			
	Max. S. to 0°		0° to Max. N.		Max. N. to 0°.		0° to Max. S.	
	Total.	Mean Daily.	Total.	Mean Daily.	Total.	Mean Daily.	Total.	Mean Daily.
	in.	in.	in.	in.	in.	in.	in.	in.
1890	6·109	0·076	4·387	0·045	6·200	0·061	5·164	0·060
1879	9·483	·108	5·556	·054	9·145	·098	7·178	·089
1884	5·143	·054	3·464	·040	4·066	·047	5·374	·055
1881	4·927	·058	5·953	·063	6·742	·069	8·103	·091
1889	4·962	·054	6·745	·068	6·065	·066	5·506	·067
1883	6·212	·069	4·882	·061	4·779	·053	6·036	·058
1885	4·511	·047	5·471	·065	7·337	·084	6·683	·069
1886	10·210	·098	6·124	·069	4·118	·051	3·760	·041
1880	8·210	·097	8·556	·090	7·224	·074	5·692	·064
1888	6·541	·073	8·389	·086	8·149	·089	4·426	·051
1887	3·870	·040	6·743	·066	5·424	·065	3·822	·045
1882	4·489	·055	6·759	·079	8·127	·079	5·806	·060
Total Rainfall.	74·667	...	73·029	...	77·376	...	67·550	...
Total Days.	1082	...	1114·5	...	1104·5	...	1082	...
Mean Daily Rainfall.	...	0·069	...	0·065	...	0·070 ?	...	0·062

period than the total rainfalls in each period. These are calculated under each case and are given under "Mean Daily." In the last three lines are given, for the whole 12 years, the total rainfall for each quadrant, the total number of days the moon was in each quadrant, and the mean daily rainfall for each quadrant, which is calculated from the two previous results. From the figures we see that if the rainfall on 1082 days, when the moon is ascending from maximum south to the equator, is compared with the rainfall on 1082 days when the moon is descending from the equator to maximum south, the latter is considerably less than the former, —less by rather more than what falls in any one year under similar conditions. In the same way if the rainfall, while the moon is ascending from equator to maximum north, is compared with the rainfall while the moon is descending from maximum north to equator, the former is much less than the latter. To compare the whole four results it is necessary to go to the mean daily rainfall for the different quadrants during the 12 years. From the last line we see that the minimum rainfall occurs as the moon descends from 0° to maximum south, and the maximum as it descends from maximum north to 0°. The rainfall as the moon ascends from 0° to maximum north is considerably less than the rainfall as the moon ascends from maximum south to 0°. But it is not sufficient for us to know that during the 12 years, 1879 to 1890, less rain fell as the moon descended from 0° to maximum south than during any other quadrant. It is interesting to know whether this period was distinctly finer than the others, that is, whether the rain was distributed as a rule over this quadrant or fell together. For this purpose I have extracted the number of times, according to the *Greenwich Observations*, that the various quadrants had less than 0·10 in. of rainfall. During the quadrant in question as the moon descended from 0° to maximum south, less than

0·10 in. of rain fell in 52 out of 160 periods, or one out of every three. As it descended from maximum north to 0°, less than 0·10 in. fell 41 times; while as it rose from maximum south to 0° this quadrant was 43 times without rain to the extent of 0·10 in., and as it rose from 0° to maximum north this quadrant had less than 0·10 in. of rainfall 45 times. So that from the analysis of the 12 years the quadrant 0° to maximum south had not only less rain than the others, but had a larger number of continuous periods of fine weather, when less than 0·10 in. of rain fell during the whole quadrant. Moreover, if the rainfall of this quadrant is compared with that of the quadrants on each side of it, less than the average fell in 60 per cent of the periods. It might be thought that heavy thunder showers or continuous rain for the same period in one or two years might sensibly affect the comparison that has been attempted between each of the quadrants. But curiously enough over 1 in. of rain was registered the same number of times in each of the quadrants during the 12 years, except in the quadrant moon ascending from 0° to maximum north. Over an inch fell 22 times during this quadrant, and 19 times during each of the other quadrants. There is no indication that these heavy falls took place during any particular month, the moon being in the northern hemisphere; but 6 of the 19 occurred in September, the moon being in the quadrant maximum south to 0°, while 5 of the 19 occurred in June, the moon being in the quadrant 0° to maximum south. Otherwise, whether the moon was north or south the heavy falls were equally distributed over all the months of the year, irrespective of the sun's declination.

In the earlier part of this paper attention has been called to the remarkable similarity in the distribution of the rainfall in 1890 and 1879 in spite of the very different quantities that fell. And if the periodic rainfalls in the above table are compared the resemblance is still more striking. In 1890 6·109 in. fell as the moon ascended from maximum south to 0°, and an equal quantity 6·200 in. fell as the moon descended from maximum north to 0°. In 1879 the quantities that fell in the same two quadrants were also practically equal to one another. In each year the minimum quantity fell as the moon ascended from 0° to maximum north, and was slightly less than what fell in the quadrant 0° to maximum south. Such consistent results deserve attention when they are not found in any other years, and when the two years in which they are found are years in which the relative position of the sun, earth, and moon to one another are practically the same throughout each of the years. Undue stress should not be laid upon these points of resemblance, but they cannot be passed over in silence.

To sum up the results obtained from analysing the Greenwich barometrical and rainfall observations from 1879 to 1890 having special reference to the declination of the sun and moon, we find that in 10 years out of the 12 the mean height of the barometer is higher when the declination of the moon is south than when it is north; that in 10 years out of the 12 it is higher when both sun and moon are south than when they are north; and that there is a distinct tendency of the rainfall to follow the barometer. In investigating the years which are exceptions an eleven year cycle has been noticed, when the earth and its satellite return to very much the same position with respect to the sun each day of the year, and the distribution of the rainfall shows some remarkable points of resemblance.

Finally, a quadrant in each lunation has been traced in which the rainfall is below the average, and the persistence of fine weather more permanent than in any other. With the hope that these results will prove to be more worthy of consideration than the shortness of the period examined justifies us at present to expect, they are brought to the notice of the Society.

DISCUSSION.

The President (Mr. E. Mawley) said that this was a very similar paper to the one Major Rawson had recently read on the "Greenwich Records of the Barometer." Although those present might not all agree with the conclusions the author had arrived at, they could not but admire the industry and enthusiasm with which the observations had been discussed. In investigations of this character there was always great danger of mistaking remarkable coincidences for the results of some natural law. Therefore, unless confirmed by greatly extending the period covered by the investigation, or by the examination of similar observations made in an altogether different part of the country, they must necessarily be received with a certain degree of caution.

Mr. W. Ellis.—The results arrived at by Major Rawson do not appear to have any real value. He says that there is a distinct tendency on the part of the rainfall to follow the barometer. This may be so, but is not surprising, and does not prove lunar influence. Major Rawson makes a point of the two years 1879 and 1890, showing similar barometer and rainfall differences, the moon's motions in these two years being nearly alike. But there is great similarity in her motions in all years, the principal difference being that in some years the moon's declination may reach as much as 28° north or south, and in other years not more than 18°, the declination reached in any year depending on the place of the moon's node (which makes one revolution in between eighteen and nineteen years). So far, therefore, as declination is concerned, the difference in all years should have the same character, if not the same magnitude. But in the twelve years discussed by Major Rawson, the excess of barometer with moon north, above that with moon south, varies from + 0·1510 in. in 1890, to − 0·1003 in. in 1882, the mean difference being − 0·0248 in. Similarly the excess of daily rainfall with moon north, above that with moon south, varies from + 0·0190 in. in 1888 to − 0·0324 in. in 1879, the mean difference being + 0·0005 in. Viewing in each case the wide range of the numbers and the small mean value, they are not suggestive of lunar influence either on atmospheric pressure or rainfall.

Let the question, however, be considered in another way. Any external body may influence our atmosphere either by its heat or by its attraction. But no sensible heat is received from the moon, and the atmosphere is uninfluenced thereby. As respects her attraction, observations made many years ago at St. Helena and Singapore indicate with considerable certainty the existence of a small atmospheric tide, the barometer being higher when the moon was on the meridian than when six hours distant therefrom, but the difference at both places was found to be less than 0·01 in. (*Philosophical Transactions*, vols. cxxxvii. and cxlii.). Water tides are also an effect of attraction, and are due mainly to the moon. The water tide is considerable; the atmosphere tide is, on the other hand, small. But the varying positions of the moon in declination influence only slightly the water tide, and if the effect on the atmospheric tide be analogous, it would be hopeless to seek to determine any relation between the declination of the moon and the height of the barometer. Again, rainfall evidently depends on disturbance of atmospheric

temperature, which being entirely a solar effect, since no heat is received from the moon, how can we expect to find any relation between the moon and rainfall? The atmospheric tide itself is difficult to determine, especially in our latitude, although probably the greatest of lunar effects; and in spite of all the attention given in past years to the subject, and the many attempts made to determine lunar influence, no other lunar meteorological effect has ever yet been satisfactorily established.

Mr. C. HARDING said that he thought the care and pains devoted to the paper was worthy of great praise. Unfortunately he had had to disagree with Major Rawson's last paper read before the Society, and he could not quite hold with his conclusions on the present one. Should the facts based on his paper be correct, they would be of great service in assisting forecasting; but Major Rawson himself even seemed doubtful as to their value for this purpose. He questioned whether it would be possible to forecast more or less rain, according to the declination of the moon.

Mr. W. H. DINES.—I cannot say that this paper has in any way altered my belief in the moon's absence of influence on the weather. It is so extremely improbable that the moon could exert any influence, that very strong evidence is required to prove that it does so. The moon's heat is so slight that it is hardly possible to detect it, and hence we may set this aside. The moon's attraction causes the tides, and must doubtless cause an atmospheric tide, but this again has never yet been detected by the barometer. The attraction is easily calculated, and is such that a weight of half a ton weighs only one single grain less when the moon is in the zenith or nadir, than when the moon is on the horizon. Again, the barometer would stand only about $\frac{1}{720}$ of an inch higher when the moon is overhead, if the tide caused be considered simply as a statical effect. It is hardly possible to suppose that such trifling differences can produce any effect.

Secondly, as to the evidence given in the paper. There is a considerable difference in the amounts of the four periods, but the difference is such as might have been expected from the law of probability. During the years 1893 and 1894 there fell at Oxshott on Sundays 5·08 in. rain, on Mondays 6·45 in., on Tuesdays 8·66, and on Wednesdays 8·56. Can any one seriously maintain from this that some unknown cause makes it fine on Sunday and wet on Tuesday and Wednesday? Of course the differences are due to the accidental occurrence of heavy falls on the two wet days and their absence on the Sundays in those two years. The 104 weeks about correspond to the number of lunations, and I may add that this was the first trial of the probability of such a difference being due to purely accidental causes that I made. It would be easy to find almost any number of similar instances, and hence I cannot agree with the author in his opinion that the phenomena are cause and effect.

Mr. H. HARRIES said it might be, as Major Rawson remarks, that "no errors but arithmetical ones" have crept in in the preparation of this and the preceding paper, but the arithmetical errors appear to be of such a nature as to suggest that the conclusions arrived at depend not upon the position of the moon, but upon the mode of dealing with the figures. If we take the specimen barometric values for the year 1879 given on p. 65 of the *Quarterly Journal*, we find 27 periods, 14 of which are on the north declination side and 13 on the south declination side. We cannot, however, compare 14 means with 13 means, for the very obvious reason that the 14th period is an overweight which exaggerates the + or − difference, or changes it from the one to the other. Exclude the 14th north declination period and we have a mean of 29·7634 in. for the other 13, and the excess over the same number of south declination values is reduced from + 0·0353 in. to + 0·0089 in. If, on the other hand, we make up the south declination side to 14 periods by taking the next succeeding series of days in

January 1880, 30·337 in., we obtain a south declination mean of 29·7961 in. to compare with the same number of periods on the other side, as printed in the *Quarterly Journal*. We have now instead of the + 0·0353 in. used in the discussion − 0·0063 in. If all other years are dealt with in this way we may possibly find every result in the barometer and rainfall tables so altered, and with the + and − signs so changed about, as to justify our arriving at entirely different conclusions from those which Major Rawson has brought before us. The differences on the yearly means are so infinitely small, and between individual periods six of one and half a dozen of the other, it becomes of the highest importance that they should be obtained by strict mathematical reasoning, otherwise we shall be arguing on tables of figures which are incorrect from beginning to end. As Major Rawson contemplates another paper of a similar nature, it is to be hoped he will reconsider the method of comparison he has thus far followed.

Major H. E. Rawson, in reply, said that Mr. Ellis had forgotten what he confessed had been unknown to himself till long after sending in his paper on the barometrical observations, that the Astronomer Royal had for seven years carried on an investigation into the influence of the moon's declination on the barometer, and had found in several years that the mean height "seemed to be increased by the moon's position in south declination." The reason for discontinuing the investigation is not given, but by the method he adopted contradictory results were obtained, and may have been the reason for abandoning it. Mr. Ellis was of course quite correct in saying that the moon's motion was very similar in all years, if he did not consider that motion with respect to any other heavenly body. Considered with respect to the sun and the earth its motion, relative to any place on the earth, such as Greenwich, was very different indeed from year to year. Every fourth year, in consequence of the revolution of the moon's apsides, the apogee of the moon will occur where the perigee occurred before. Every fourth year the periods when the moon is north and south of the equator will be exactly reversed; during those days of each month that the moon was north of the equator it will be south, and *vice versâ*. Considering the motion of the moon round the earth in an ellipse, which is itself in a twofold state of motion—one of advance and one of tilt—it was a matter worth noticing in the period under discussion that in the eleventh year there was a similarity in the motion of the moon which does not appear in any other year.

Major Rawson was obliged to Mr. Harries for his criticism on the method adopted. His object in bringing the matter to the notice of the Society was, first, to invite criticism; second, to ascertain whether he was treading on old ground. While we are unaware of the cause why the barometer is found to be higher with the moon south of the equator than when north, the method adopted seems to be free from all charge of prejudice. Does Mr. Harries think that the moon's influence for a 14th period causes the overweight he refers to?

He quite shared the opinion of those who found it extremely difficult to believe in the moon's attraction or heat being the direct cause of the facts which his investigations had brought out. He wished, in conclusion, to take this, the first opportunity of reporting to the Society that an examination of the Greenwich observations for the fifty-two years (1841-92), which have been published, showed that for an epoch of twenty-three consecutive years, with but five exceptions, the barometer was higher with the moon north of the equator than with the moon south; while during the epochs on each side (also with but few exceptions), the barometer is higher with the moon south of the equator than with the moon north. Thus of the years discussed in this and the previous paper, 1879 is the last year of an epoch, and forms no exception. From 1880 to 1892, the year 1890 is the only exception. Some very interesting results also appear in connection with the eleven-year interval which has been referred to in the papers.

WEATHER FORECASTS AND STORM WARNINGS: HOW THEY ARE PREPARED AND DISSEMINATED.

By FREDERIC GASTER, F.R.Met.Soc.

A Lecture delivered before the Royal Meteorological Society, March 18, 1896.

Having been invited by the Council to bring before the Fellows a statement, in the form of a lecture, as to the manner in which weather forecasts and storm warnings are prepared and made known in this country, I have acceded with pleasure, and have to acknowledge with many thanks the honour which has been conferred on me by the request. In performing the task, however, I have to ask the indulgence of those who are already acquainted with the main features of the work, while I take them, and those who are not so familiar with the subject, through each stage of the proceedings, so that in the end we may all come to a clear and satisfactory perception of the principles on which the work is based.

Now, of the instruments employed in this work the barometer occupies a position so pre-eminently important that it is necessary to recall clearly its construction, and to consider what is indicated by its readings. We take a tube about 33 inches in length, closed at one end and open at the other; we fill this tube with mercury, and having expelled all the air, invert it in a vessel (or cistern) of mercury, so that the open end of the tube is below the level of the mercury in the vessel. The mercury in the tube at once sinks to a certain level, but the larger portion (about 30 inches in length) remains in the tube, leaving a vacuum in the upper part. Why does not the whole of the mercury leave the tube? Simply because it is maintained in its position by the pressure of the air on the mercury in the cistern. Remove that pressure by an air-pump, and all the mercury will come out of the tube; let in the air again and the mercury will at once reascend to the height previously marked, but will never *fill* the tube. As a consequence of this we see that, should the atmospheric pressure in the ordinary course of nature decrease, a further portion of the mercury will flow out of the tube into the cistern, and we shall say "the barometer is falling"; while an increase of the atmospheric pressure will force a larger quantity of the mercury into the tube, and we shall say "the barometer is rising." Thus we come to two sets of terms—

(1) Barometer high = atmospheric pressure in excess of the normal,
Barometer low = atmospheric pressure in defect of the normal; and
(2) Barometer falling = atmospheric pressure decreasing,
Barometer rising = atmospheric pressure increasing,

the rate of change being described as slow, moderate, or rapid, according to circumstances.

This is all that a single, isolated instrument shows us; but there can be no doubt that by the careful consideration of its actual height and its rate of rising or falling, in connection with the simultaneous change in the direction and force of the wind, temperature, humidity of the air, and

the increase or decrease in the quantity and density of the clouds and their height, isolated observers have been for years enabled to arrive at very shrewd conclusions as to the character of weather approaching their neighbourhood. Farmers, shepherds, and sailors, by constant practice, are among the most apt of such judges, especially when the physical features of their own locality at the time of observation form an element in leading them to their conclusions.

But the question long ago suggested itself to some, that if we could obtain simultaneous readings of the barometer, made at a considerable number of positions scattered over a wide area of country, we might by putting them on a map and looking at them in connection with the wind and weather, prevailing at the same time, arrive at some better conclusions as to the form and nature of the weather systems with which we have to do, and by comparing chart with chart learn something, perhaps much, more of the movements of such systems, and finally be prepared to deal with them for the good of mankind. The first endeavours in this direction were made by our forefathers in discussing the conditions prevalent during violent storms. The earlier investigators found that in these storms the wind tended to circulate round a central area in which the barometer was low, and thus it came about that such storms were called "cyclones." It was not till later that the cases of ordinary and lighter winds were similarly discussed.[1] The importance of such investigations and of the facts which they disclosed, gradually forced itself on the public, until in the present day hardly any civilised country is without its Meteorological Office or Weather Bureau, in which one of the duties is to establish a series of widely spread stations, which shall communicate by telegraph with a central office once, twice, or thrice daily, at certain fixed hours reporting the pressure and temperature of the air, the direction and force of the wind, the weather, etc., as soon as the observations had been made.

In the map, Fig. 1 (p. 214), we have the positions and names of the stations in the British Islands from which such information is received, together with many foreign stations,[2] the information from which is, by a courteous system of international exchange, available for publication in the *Daily Weather Report*. From this map it will be seen that the stations cover the whole of the British Islands and many parts of Western and North-western Europe. From all of these localities telegrams are received once, from several of the others twice, and from a considerable number of them three times a day, the hours of observation being 8 a.m., 2 p.m., and 6 p.m. Now let us see what the barometric readings taken at one of these epochs show us. In Fig. 2 (p. 215) we have a set plotted to the positions of the stations, and it is at once evident that not only are the readings unlike one another, but that all the lowest readings are gathered over or around one particular position—viz. the east of Scotland—while the highest are found in France and Germany, and that the values increase steadily from the former to the latter region. We want to know more

[1] It is in no way proposed to go minutely into the history of this work, but merely to mention it with the object of showing how certain terms came into use in dealing with weather systems.

[2] The map is not large enough to give the positions of Lisbon and P. Delgada (Azores), information from which is supplied by the Portuguese authorities.

definitely, however, the form of the area in which such readings are congregated, and to do this we find out the points at which the readings are precisely similar, and join them by lines. In the present case it is evident that the reading of 29·50 in. would lie between Aberdeen (29·46) and Leith (29·58), between Aberdeen and Ardrossan, (29·62) between

FIG. 1.

Aberdeen and Nairn (29·51), between Aberdeen and Wick, and between Aberdeen and Skudesnaes—in fact, between the two last named stations the readings of 29·5, 29·6, 29·7, and 29·8 will all be found at certain positions along a straight line joining the stations. We place a dot on the map where each reading of 29·5 in. is to be found, and we then join them by a curved line, and at once it becomes evident that the line takes a somewhat oval form. On drawing in a similar way the lines joining the

dots which mark the values of 29·6 in. and 29·7 in. we shall find that they run in a course somewhat parallel to that of 29·5 in., and enclose an oval-shaped area in which the barometer stands lower than in the regions adjacent. We therefore call this a region of "low barometer" or "low pressure," and the lines are called "isobars." On continuing the process, however, it is found that the line for 29·8 in. shows a tendency at its extremities, to draw away from this low pressure area; those of 29·9 in. and 30·0 in. show a still greater tendency in this direction, and when we come to those for 30·1 in. and 30·2 in. we find them enclosing another somewhat oval area, but in this the barometric readings are higher than those in the adjacent regions. This area is termed an area of "high barometer" or "high pressure," as opposed to those of low pressure previously described,[1] and if the whole of the earth's surface were so treated several of these areas, both of high and low pressure, would be discovered.

The next question which suggests itself is this. Is there any connection between these high and low pressure systems with which we have

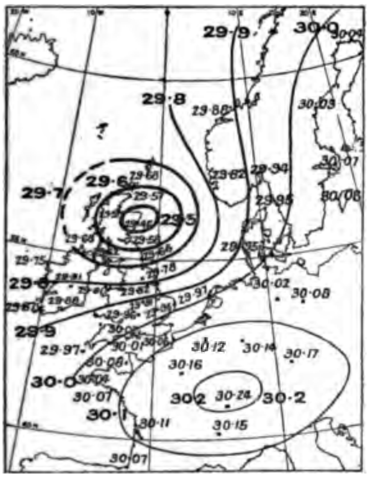


FIG. 2.

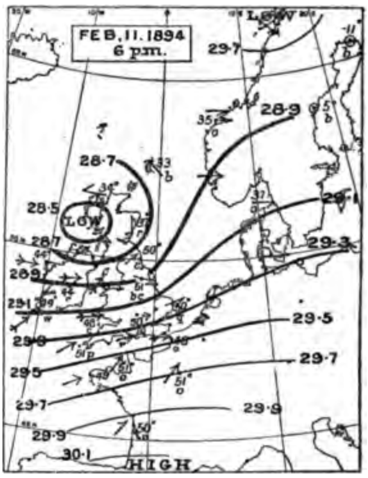


FIG. 3.

become acquainted, and the winds and weather observed in their neighbourhood? Undoubtedly there is; and to make that connection evident we must give up the hypothetical diagram in Fig. 2, and refer to Figs. 3 and 4 (p. 216), which are drawn from actual observation. Both of them are compiled from observations made in winter, and are therefore intercomparable. Fig. 3 shows a large area of low pressure, having its central part (in which the barometer is below 28·5 in.) lying over and off the west of Scotland. The cylonic system covers the whole of the United Kingdom, and the barometric "gradients" (or differences of pressure for a given unit of distance) are steep. The arrows on the diagram show the winds

[1] The isobars prevailing are as a rule not so regularly formed as those in the diagram, which is a typical case drawn merely to aid those who read this lecture to understand thoroughly the main principles observed in drawing isobaric maps.

prevailing at the time, and of these an explanation is given in the footnote.[1] What do they show? Westerly and South-westerly winds strong to gale in force on all our western coasts, strong West-south-westerly winds in the channel, but a moderate Southerly breeze off the east of Scotland, a South-easterly breeze at Sumburgh Head, and an Easterly wind in the Minch. In Norway the wind is Westerly, influenced by another system which had previously passed over us, and was disappearing over the north of Russia. Now look at the temperatures; they range between 51° and 49° over all the southern half of the area, but are as low as 30° to 37° in the north, where either the wind was Easterly, or the pressure distribution was approaching more nearly to that of the "high pressure" systems than to the low-pressure system with which we have to do. Mark, too, the weather—squally and rainy on almost all our coasts, with snow in the south-west of Norway and in the north of Scotland. Even as far south as Rochefort the sky is overcast; and the morning observations of the following day show that gales and rains had been very general.

We come now to Fig. 4. Here we have a high-pressure system, the central area of which lies over the Christiania Fjord, where the readings exceed 31·0 in., while the system extends southwards to the middle of France, and westwards over the whole of the United Kingdom. The winds are North-easterly over Denmark and North Germany, Easterly over England, Easterly and South-easterly in Ireland, and South-easterly to Southerly at the Scotch stations. Here also we have a circulation of wind round the system, but its tendency is to draw *outwards, from* the centre, whereas in the case of the low pressure system it tended to flow *inwards, towards* the centre. Moreover, in the high-pressure system the winds are moderate to light in force, as opposed to the gales and strong winds of the low-pressure system, and had the specimen chosen for the high-pressure system been, as is often the case, a system of larger area and slighter intensity, the winds would have been lighter still and in many regions calm. In fact, variable airs and calms usually prevail over the central parts of the high-pressure areas, while strong winds mark those of low pressure. Let us now examine the temperatures in this system—they are all very low, the only readings which exceed the freezing-point being those in the west of Ireland, while those reported from Germany and France are as low as 18° or 19°. The weather, too, is fine and dry, as opposed to the squally rainy conditions shown in Fig. 3.

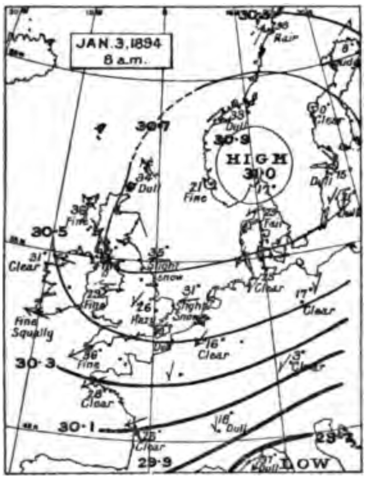


FIG. 4.

[1] The force of the wind is shown on the various diagrams by the number of barbs and feathers on the arrows. Thus two barbs and four feathers indicate a violent gale; two barbs and two feathers a fresh gale; two barbs and no feathers a moderate gale or fresh wind; one barb only, a moderate to light wind. A small circle indicates a calm.

We learn, therefore, from these illustrations, that the two systems, the high and the low pressure, are diametrically the opposite of one another in pressure, temperature, wind, and weather; and, as the wind draws *out from* the high-pressure centres, and *in towards* the low, it is evident that the former systems "feed" the latter at the surface of the earth; and it is only reasonable to suppose that the reverse of this operation takes place in the higher regions of the atmosphere.

One or two more facts must be noted before we tabulate the important facts at which we have arrived. The first is that in summer time the anticyclone is the warm weather system, as owing to the fineness of its weather, and the many hours of sunshine the solar rays are felt very strongly in heating the earth and air, while the low-pressure systems, owing to the density of their clouds, and the effect of their rains, become the cold-weather systems of this season by cutting off the solar rays. As the apparently circular movement of the air round the low-pressure system had led to their being called "cyclones" (from *kuklos*, a circle), the opposite circulation round the high-pressure systems gave rise to the term "anticyclones" as applied to them. Again, from the fact that in cyclones the barometric column is depressed below the level which it maintains in adjacent regions, the systems have come to be called "depressions"; and it has been suggested that for the opposite reasons the anticyclones might with equal propriety be termed "appressions."

In the following table there will be found all these normal characteristics of the primary systems of weather to which we are subject—a table, the value of which will be apparent to every one who takes any interest in the matter.

Pressure Systems and their Normal Characteristics.

Low Pressure.	High Pressure.
Names.	
Cyclones. Depressions.	Anticyclones. Appressions.
Winds.	
Strong in force; at times a severe gale, or hurricane. Circulate left-handed round the centre of the system. Draw in spirally *towards* the centre.	Light in force, often calm. Circulate right-handed round the centre of the system. Draw out *from* the centre towards the neighbouring cyclones.
Temperature.	
Low in summer. High in winter.	High in summer. Low in winter.
Weather.	
Rough and squally. Rain in summer, snow in winter, thunderstorms in both seasons, but especially in summer.	Quiet and dry. Cloudless and bright in summer, with haze at times; foggy or bright in winter.

We come next to the consideration of the movements of these systems —are they at all dependent the one on the other? and if so in what way? With regard to the anticyclones no rule whatever has been recognised as to their movements; but the movements of the cyclones appear to be in a limited degree dependent on their position with regard to the anticyclones—it being found generally that cyclones tend to move round the anticyclones from left to right—so that if pressure be highest in an anticyclone lying over Continental Europe and having its central area over Germany and the Baltic, then a depression arriving off the west of Ireland from the Atlantic will move north-eastward, outside our west and north-west coasts, and travel away over Northern Europe towards Siberia. On the contrary, with pressure highest over Northern Europe and stretching out over Scandinavia towards Scotland, any depression which may appear over North Germany (and these are usually very slight) will tend to move westward over the Netherlands, and the north of France. As a rule these latter systems are secondary to a larger, and more general (primary) system lying at that time over the Mediterranean Sea or Southern Europe. Before going more fully into this question, however, we must get some further insight into what are termed "secondary" systems.

Secondary systems may be either of the low or high pressure type, and perhaps it will be well in considering them to confine our attention in the first place to the former. They are observed sometimes as *small*

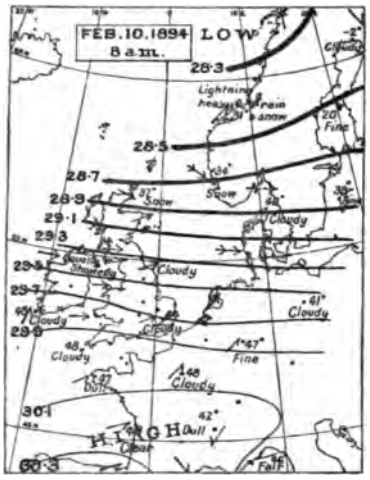


FIG. 5.

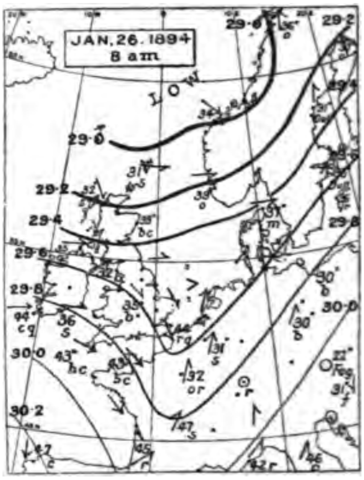


FIG. 6.

cyclones, tending to move round their primaries from left to right—as if carried on by the general movement of the air-currents in which they are developed—at other times as *hemicyclones*, *i.e.* systems of which only one half of a cyclone (the half remote from their primary) is to be traced; they obey the same law of movement as is observed with their more fully developed brethren. Other secondaries assume the form of the letter V, and are termed "V-shaped" systems: they are ordinarily developed between two anticyclones as a primary depression passes by the mouth of the

hollow which separates them. A chart showing both the cyclonic and hemicyclonic secondary systems will be found in Fig. 5 (p. 218) for 8 a.m. on February 10, 1894, where the primary depression is to the northward of the Shetland Isles; the secondary cyclone is shown lying over Kent, while a hemicyclone is approaching the west of Scotland from the Atlantic. The effect of such secondary systems is to throw the bad weather which would have prevailed closely round the primary system to a greater distance from its centre—the space intervening between the secondary and primary being marked by a very temporary spell of bright weather to be succeeded by the disturbed conditions normal to the primary when the secondary has passed. "V-shaped" disturbances are marked, as far as the weather is concerned, by most of the features which maintain in secondary cyclones or hemicyclones, but the winds in their front and rear are set with regard to one another at an angle so acute, that when their central line (or diameter)

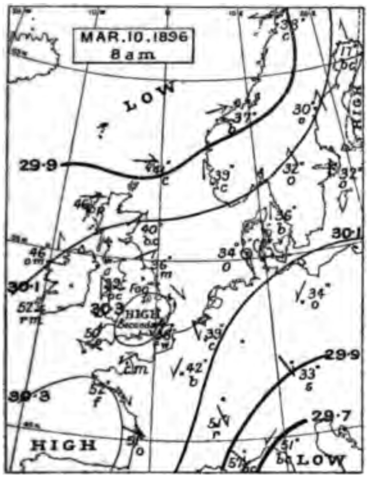


FIG. 7.

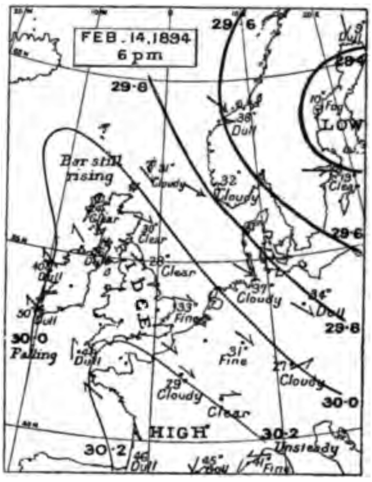


FIG. 8.

passes over any station, the winds shift abruptly, sometimes momentarily, through a considerable angle, in a sharp squall, and if the gradients on the rear side be steep, the change is often productive of serious damage to shipping, owing to the unexpected change, and the severity of the gale which is developed. A good instance of this is shown in the chart for 8 a.m. on January 26, 1894 (Fig 6, p. 218). It is not very uncommon for small cyclonic systems of great intensity, commonly called "tornados," to be developed in the apex of the "V," and the evil qualities of these small, but most destructive, storms are sufficiently well known, although happily in this country we know very little of their ravages.

Let us now turn to the secondary high-pressure systems. Here we find varieties, almost precisely the reverse of the secondaries which belong to the low-pressure class. The similarity in their outline, as shown by the isobars, is simply remarkable, but the fact that in one class the pressure is in excess, while in the other it is in defect of that in the surrounding regions, makes all the difference as to their other characteristics. We

have secondary anticyclones, pure and simple, such as is shown in Fig. 7 (p. 219) for 8 a.m. on March 10, 1896, in which the primary anticyclone covers the Bay of Biscay and neighbouring parts of the Atlantic, while the secondary lies over the midland and southern counties of England. The effect of this secondary is (as in the case of the secondary cyclone) to throw out the conditions observed in the primary much farther to the northward (*i.e.* away from the centre of the system) than would have been the case had the secondary not existed. The next form of secondary high-pressure system is that called the "ridge," a feature shown to some extent in the Fig. last referred to, but much more strongly in Fig. 8 (p. 219), which represents the conditions prevailing at 6 p.m. on February 14, 1894. On this occasion a large anticyclone lay over France, Western Germany, and the south of our islands, but the "ridge" spread northward (like a spur from a mountain chain) covering the whole of the British Islands, and almost touching the Farö Isles. The winds and weather in this kind of system are exactly the opposite of those in the "V-shaped" depression, and spread out the anticyclonic condition of the primary high-pressure area much farther to the north-westward than would have occurred had the ridge not been present. This form is found extending from anticyclones between two depressions as they move along the margin of the high-pressure area, and may perhaps be considered as the natural result of such an arrangement rather than an independent system of itself—it being hard to conceive that two somewhat circular depressions could follow one another round an appression without such a ridge intervening. A further development of this form of secondary is found in the union of two "ridges" emanating from two different high-pressure systems, and uniting in the form of a "col." Such a formation is shown in the chart for 6 p.m. on February 26, 1896 (Fig. 9, p. 221), when one of the two high-pressure areas lay over Ireland and the adjacent parts of the Atlantic, the other over Scandinavia and Northern Europe, the two being united by the "col" stretching across England, the south of Scotland, and the North Sea. The adjacent low-pressure systems are shown lying one to the northward of Scotland, the other over the south of France and the Gulf of Genoa, and are well marked. Within the area covered by the "col" the weather is fine, the winds are light, and the night temperatures (in winter) are low; in fact, the anticyclonic condition of the two systems which the col unites are continued throughout its length. The two anticyclones, of course, need not occupy the positions shown in the illustration in order that a "col" should unite them, but it is necessary that each should extend towards the other in the form of a "ridge," or the weather conditions here described would not hold true. Should the major axes of the anticyclones be parallel one to another there would, in fact, be produced a complex condition which has hitherto been known by the term "trough," and to which attention will be shortly directed.

It is evident, from what has already been stated, that if the distribution of pressure were always in accordance with one of the types hitherto described, and if the changes were of a simple and regular character, the forecasting of weather and the issue of warnings for storms would be matters comparatively easy of execution; but this is not so. Both the low and the high-pressure areas undergo at times important alterations, both of intensity and of form, as they approach or pass over

our area. Sometimes a depression which, on advancing towards us, is large and deep, fills up almost suddenly, and the warnings issued turn out to be wholly or partially unnecessary; at other rare times a disturbance apparently of slight importance develops an energy in no way foreshadowed by the barometrical indications, as far as our present knowledge enables us to understand them, and storms are then experienced where none were looked for. More commonly the advancing depression extends over a larger area than it appeared likely to cover, and consequently a rather larger part of our coasts than had been warned experiences a gale. On other occasions a sudden increase of pressure far outside our area of observation will develop steep gradients where only slight ones were shown before, and gales result on coasts which had not appeared to be threatened. All such matters as these are causes of inquiry and careful consideration, and it is cheering to be able to say they are gradually

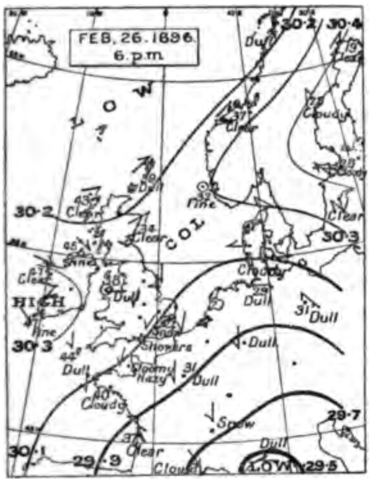


FIG. 9.

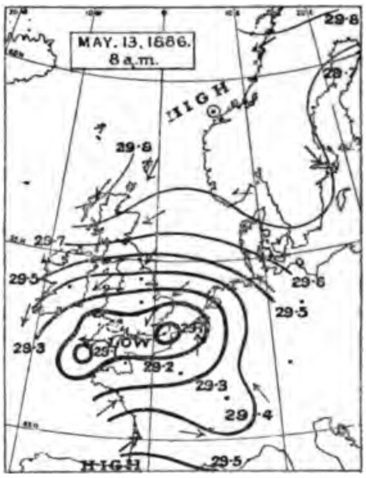


FIG. 10.

coming more and more within the grasp of those whose duty it is to perform the very trying and often thankless task of issuing the warnings.

With regard to mere "weather" conditions, however, there is a distribution of pressure which produces rains, so heavy and so fitful, that it can at present be forecasted only with great difficulty, and at times baffles entirely all attempts to deal with it. I mean the condition which in the official publications has been termed a "trough" of low pressure. This must not be confused with the "trough" of a depression referred to by Mr. Abercromby in his works, and which, as a meteorological entity, has probably no real existence. An instance of a trough is found in the conditions which prevailed between May 11th and 14th, 1886. The distribution of pressure at the time of greatest intensity is shown in Fig. 10 for 8 a.m on May 13th. At that time there were two high-pressure systems, one over the northern parts of our area, the other over Spain and the Mediterranean, but they were separated by an elongated area (or trough) of low pressure lying over the English Channel, the Scilly Islands,

and the south of England. In this there were three distinct minima, one over the Scilly Islands, a second over the northern part of Devonshire, and a third over the Straits of Dover; and, as a rule, it will be found that such a distribution of pressure is favourable for the development of local depressions which, while they may not produce much wind, cause heavy falls of rain in many places. Torrents of rain had prevailed over our midland and north-western counties, and in the east of Ireland, with Easterly and North-easterly winds. A very similar condition has occurred on the morning of the day on which this lecture is delivered (March 18, 1896), and we all remember how steadily the rain has poured down for many hours together in London. There are other minor disturbances to which attention might be drawn, *e.g.* the thunderstorm disturbances of summer, and other local systems, most of them having the accompaniment of heavy rain—the bulk of it coming with an Easterly wind—but time forbids their detailed consideration at present.

Let us now see what we can gather from the facts which have been adduced so far. We have considered the main features of high and low pressure systems and their bearing on one another, and have noticed the principal forms of primary and secondary systems, and the laws which appear to govern their movements. If these features be as has been stated, it is obvious that in preparing forecasts, or issuing storm warnings, our first consideration must be the positions in which the pressure is highest and where lowest, then the steepness of the gradients, and the indications (if any) of the approach of any depressions, and whether they appear to be large or small, deep or shallow, primary or secondary. Then come the questions as to what coasts are likely to be affected, and the further question whether, by the rate of the barometric fall, and the manner in which it is spreading, whether the high or the low pressure system is obtaining the mastery, and whether one system is spreading decidedly over one neighbourhood to the exclusion of the other.

Let us take a few typical maps and see what they show. We have, first of all, in the map for 8 a.m. on December 25, 1895 (Fig. 11, p. 223), a high-pressure area lying over Northern Europe, a primary depression off our south-western coasts, and a shallow secondary over the Channel. South-easterly winds were then general over Ireland and Scotland, and were blowing hard; torrents of cold rain were falling in the south-east of Ireland, some rain and snow over our south-eastern counties, and very slight snow on the north-east of Scotland; as the depression filled up these conditions gave way to finer weather. Take next the conditions prevalent on February 10, 1894 (Fig. 5, p. 218), when with high pressure over France and very low pressure over the north of Scandinavia, the wind was generally Westerly, moderate to fresh at the southern stations, and strong to a gale in the north, and the little rain which was reported fell almost entirely over the northern parts of the kingdom. Now let us take the map for January 16, 1896 (Fig. 12, p. 223). In this case the barometer is highest over the Bay of Biscay, lowest in a depression over the southern parts of Scandinavia, the gradients being steepest over the North Sea. We notice that in this case the winds are Westerly to Northerly, and are blowing hard over the Skagerrack, and strongly over the North Sea and Scotland, in all of which regions squalls of rain, graupel, and snow are prevalent, while very fine weather is being experienced on the south-west coast of

the British Islands and the west coast of France. In the next, and last case, that of January 3, 1894, and already referred to as Fig. 4, p. 216, we have the highest pressures over Scandinavia, and the lowest over the Mediterranean, but with gradients slight except in the south and south-east. The winds we find are Easterly (NE to SE), and blow hard on the Dutch coast, through the Straits of Dover, and at the mouth of the Thames. The weather is extremely cold, and some very shallow secondary disturbances over the southern half of our area are causing snow squalls, in the south-east and east, while in the west and north the weather is fine and bright. From these four types of pressure distribution it is evident that the main condition on which the direction and force of the wind depends is the distribution of pressure over the area with which we are dealing; the strength of the wind varies with the steepness of the gradients, the parts of the area affected by disturbed weather depend on their

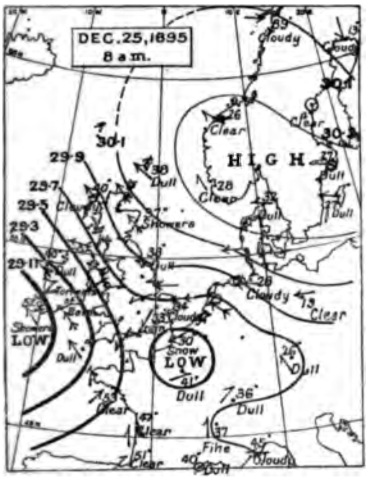


Fig. 11.

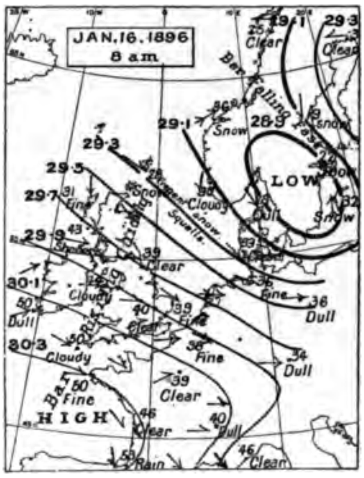


Fig. 12.

proximity to the region of lowest pressure, or to their being affected by the secondary systems which move round the primary in its passage. Given as the statistical condition on which our judgment is based, the distribution of pressure at the time of observation—we have to consider the rate of fall in the barometer in the different sections, and the tendency of the wind to draw cyclonically round any region where the fall is most decided—these details point to the direction from which new disturbances, if any, may be expected. Temperature plays a most important part as an aid to the other observations, as the thermometer, no matter how low, almost invariably rises in front of an advancing depression, and in some instances the rise is very rapid. Again, if two depressions are following one another across the kingdom—say from west to east—and the ridge which separates them should pass over the country in the night—then, in the winter time, no matter how warm and wet the winds of the first disturbance may have been, the fall of the thermometer as it passes off is very rapid, and the subse-

quent rise as the new one comes on is equally striking. In this way it is recognised that if after a South-westerly gale and rain the sky clears very quickly, and there is great terrestrial radiation of heat at night, perhaps causing sharp frost on the grass, this occurrence is indicative of the early advance of a new depression with warm winds and rains, as before. Even in conditions when cold North-westerly winds and snow squalls are prevalent over our northern and eastern districts, owing to some depression lying over Scandinavia, or the eastern shores of the North Sea, the approach of any new disturbance from the north-westward or northward is heralded by a decided rise of the thermometer, first at the northern, and later on at the eastern and southern stations, accompanied by a temporary backing of the wind to West or South-west.

In Fig. 13 we have a diagram giving a hypothetical instance of a distribution of pressure over the Atlantic, showing certain anticyclones

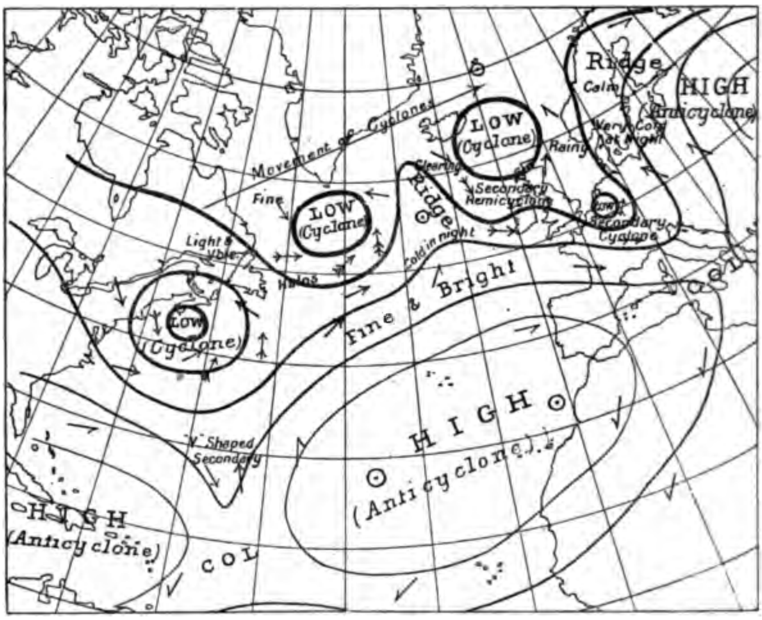


FIG. 13.

with depressions moving along their northern side, and showing every form of secondary system referred to in this paper. It is a modification of a diagram published by Mr. Abercromby some years ago in his book entitled *Weather*, and is very instructive.

From the facts that have been all too briefly touched upon it must be evident that we still require a clearer and more certain knowledge of the nature of the atmospheric circulation—of the manner in which the air rises in depressions, and comes down to earth again in the anticyclones. We require some means of ascertaining the movements in the higher regions of the atmosphere, and to accomplish this various means have been tried. Ballooning has been attempted, but this is unreliable, and is of

course impossible just at the time when the indications would be most valuable—viz. immediately within the swirl of storms or in various positions around them. Guns have been employed for firing shells high into the air, where, on exploding, they produce a cloud of dense smoke, the movements of which can be watched. A more usual and permanent plan has been to build observatories on the peak of some mountain—such as that on the top of Ben Nevis in our islands, on the Puy-de-Dôme and the Pic du Midi in France, and several others in various countries. The observations of pressure, temperature, and vapour, made simultaneously at the top and at the base of such mountains, are yielding much valuable information to meteorology and other branches of physical science; but up to the present they have not been of so much service, as aids to the forecasting of weather, as it was hoped they might be—probably owing chiefly to the obstruction which the hill, or range of hills, offers to the wind currents, so that the direction and force of the winds recorded are often of a purely local character, and do not indicate accurately the general movement of the air current in which they are situated. We are consequently thrown back upon observations of clouds and their movements. The value of such observations is steadily increasing, because much has been done to settle the question as to the altitude above the sea at which certain well-defined forms usually appear. Take in the first case the *Cumulus*, or heap cloud, in which the particles of water are found to be drawn together in large masses, which rise from an almost horizontal base, and often tower up, like masses of wool, to a great height. The variations in the size and density of such clouds are of themselves of great value in judging of coming weather, but the altitude of their base being approximately known, their movements show the direction in which the air current is travelling in which they (among the lowest forms) are floating. Then there are some of the higher forms of *Sheet* (or *Stratus*) clouds, which sometimes appear as a pall (*pallium*), and, when broken into detached portions, are easily recognised by the form of the cloudlets so developed. These, too, show by their movements the direction and velocity in which their air current is travelling, and their height can be approximately estimated. Still higher we have clouds of the *Cirrus* type, floating at about 25,000 to 30,000 feet, or even more, above the sea. Such clouds are readily known by their very delicate and filamentary structure, appearing sometimes as feathers, sometimes like locks of hair, sometimes like bunches of seaweed, and at others in great white masses or sheets, through which the sun and moon can be seen, often surrounded by a halo. Much has already been done to show the connection between the movements of these clouds and those of depressions in their neighbourhood, and much more will undoubtedly be ascertained ere long, when an accurate knowledge of the different forms of clouds and their classification has become more general among observers than it is at present. There is, however, a serious drawback even to this branch of the work. It is that thick lower clouds often prevent us from observing those at the higher levels, especially within the area covered by a storm, and we are then unable to obtain the very information we require. Observations on or outside the margins of such storms have, however, proved of enormous value already, and such observations should, if possible, be made more generally. In my opinion they are the most

valuable of all the "tallies" on the movements of the upper currents which have ever been proposed; and there can be no doubt that in a short time, when the methods of observing them are improved, their importance will be more fully recognised.

It has been frequently suggested that the accuracy of the forecasts and storm warnings might be materially improved if we received information daily by wire from the United States, as to the general distribution of pressure over North America, and the storms which had left their shores moving eastwards, together with reports of the weather experienced by large steam vessels on their way from this country to the United States. The system was tried a few years ago for several months. It was shown then that a certain number of storms did probably come across the Atlantic and affect the weather on our coasts to a serious extent. More, however, passed away so far to the northward that their influence on our weather was not appreciable; others broke up in their journey, and the plan was abandoned, because not only was the information useless as a direct warning, but because the knowledge that a storm was prevailing over the Western Atlantic often caused those on this side to issue warnings prematurely. To cry "Wolf! wolf!" too often, is sufficient to ruin the reputation of any system of warning.

The proprietors of the *New York Herald* endeavoured for some years to warn our shores directly from the United States, and any one who wishes to judge of their success should read Mr. Scott's report of an examination into their value published while the system was in progress. The warnings were apparently abandoned for some years, but during the past few months there has been a resuscitation of them in the *Times* and some other papers. A more lamentable failure it is not possible to imagine.

Others have proposed that a vessel moored some few hundreds of miles to the westward of Ireland, and connected by an electric cable with this country, could telegraph information of advancing storms which would make the storm warnings almost perfect. From experience of the value of reports from an isolated station I must say I have no faith in such an experiment, even if the maintenance of the vessel in the position assigned to it, and the continuity of the electric communication could be kept up. Of the cost I say nothing. I think that at least three such vessels would be required, moored say in long. 28° to 30° W., and in lat. 50°, 55°, and 60° N., on a line between the Azores and Iceland; The cost of such a system, if it could be maintained, would be enormously in excess of its value to mariners.

This brings us to the close of the first part of our subject. We have now to consider briefly in what manner the forecasts and storm warnings are made known.

The forecasts which are issued to the public generally are drawn up twice daily—viz. at 11 a.m., from the 8 a.m. observations, and at 8.30 p.m., from the 6 p.m. observations. The former appear in many of the afternoon and evening newspapers; they are posted up soon after noon at the Mansion House, and several other places both in the City and at the West End, and are supplied for a small annual fee to such of the clubs as subscribe for them. The evening forecasts are supplied to all the principal newspapers, either directly or through the various news agencies, throughout the kingdom, and thus appear on the following

morning in all parts of the British Islands. Forecasts, prepared at 3.30 p.m., to cover the same period of time as those prepared at 8.30 p.m., are issued gratuitously during the hay-harvest season to certain selected agriculturists in various parts of the kingdom; and any of them (11 a.m., 3.30 p.m., or 8.30 p.m.) are issued either by wire, or letter, or personally to applicants, who pay a small fee for the information in addition to the cost of transmission. The success of such forecasts is shown by the fact that year after year the same applicants are desirous of receiving and publishing (and in many cases of paying for) them, for weeks together. But it is to be understood the forecasts are prepared for large districts or areas of country, and that at times, when quite right for such districts as a whole, they are somewhat faulty in certain localities, where some peculiarity in the position of a station, with regard to ranges of hills, modifies the weather in that region, and renders the result less satisfactory. The districts for which the forecasts are prepared are shown in Fig. 14.

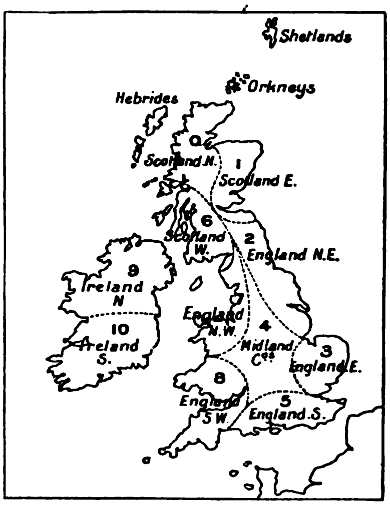


Fig. 14.

The storm warnings are made known by being telegraphed to a large number of stations on our coasts, and in these places the fact that such a warning has been received is made known to the shipping authorities and others by the hoisting of a black "cone," which indicates the probability of rough weather—commencing from some southerly direction, when the apex of the cone is downward, and from some northerly direction, when it is upward. The telegram itself is exhibited, in a frame, in some prominent and well-known position at each port, and explanatory pamphlets are distributed from time to time among the seafaring community at the positions referred to, and are published in many nautical works as well. In addition to this the information is communicated to the daily newspapers in a manner similar to that adopted in the case of the forecasts. The results of these storm warnings are very satisfactory, the coast gales being less liable to local influences than the ordinary winds and weather at inland stations. Moreover, the fact that warnings are circulated by telegraph increases their practical value, by annihilating so much of the time which is necessary ere the forecasts can appear in print.

The winds observed not only at the telegraphic reporting stations of the Meteorological Office, but also by the observations made at many lighthouses and light-vessels round our coasts, are used in checking the accuracy for these storm signals, with the result that in 1894-95 no less than 93 per cent of the warnings were justified by the occurrence either of gales or strong squally winds. In Fig. 15 (p. 228) are two curves, taken from the last annual Report of the Meteorological Office, and

showing the improvement which has been observed in this work during the past ten years.

It is sufficient to point out the gradual increase in the percentage of the accurate warnings, and the decrease in the percentage of the unsuccessful warnings, in order to show that the work is improving greatly. Of course in some years the gales experienced are less strong than in other years; and as the warnings have to be issued on very slender information, if they are to reach the coasts in time to be of practical value, it happens that in some years the percentage of success will be smaller, and that the proportion of warnings justified by strong squally winds to those

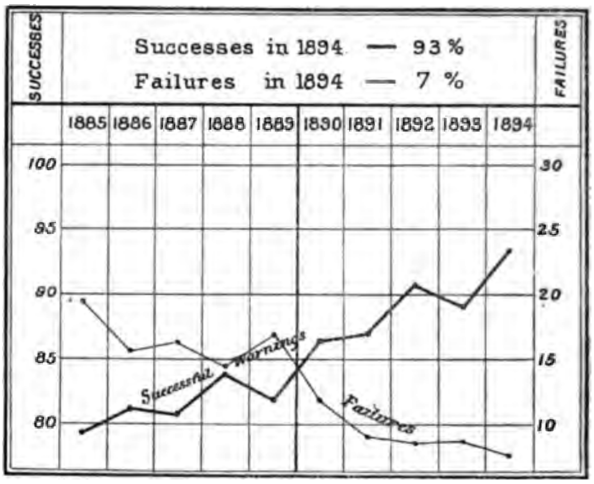


FIG. 15.

justified by strong gales will be increased somewhat. These are defects to be remedied only by constant study, by a gradual and judicious increase of the area covered by the observing stations, and of accuracy both in the observations themselves and in their subsequent transmission by wire. On several occasions whole coasts have been needlessly warned, either because a wrong barometric reading has been taken at some important station, or a telegraphic error has crept into the message in course of transmission; and the only thing to do was to act promptly and warn the coasts, or to risk the advent of a bad gale without the coasts having been warned.

Here I must close. Much has been left unsaid which might have been said if time permitted; but all that has been attempted has been to explain the broad principles which are acted on in carrying out the work of forecasting the weather and warning the shipping of the British Islands.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 18, 1896.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

ALBERT MORLEY CLARKE, All Saints Terrace, Witham;
JAMES GEORGE HAWTHORN, 41 East India Dock Road, E.;
JAMES GEORGE HOLMES, Thorne Lodge, Oakfield Grove, Clifton, Bristol; and
HARRY WILLIAM TAYLOR, Newburn-on-Tyne,
were balloted for and duly elected Fellows of the Society.

Mr. FREDERIC GASTER, F.R.Met.Soc., gave a Lecture on "Weather Forecasts and Storm Warnings: How they are prepared and disseminated," which was illustrated by instruments, diagrams, and lantern slides (p. 212).

April 15, 1896.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

ROBERT FORTESCUE FOX, M.D., M.R.C.P., Strathpeffer Spa, N.B.,
was balloted for and duly elected a Fellow of the Society.

The following communications were read:—

"THE MEAN AMOUNT OF CLOUD ON EACH DAY OF THE YEAR AT THE ROYAL OBSERVATORY, GREENWICH, ON THE AVERAGE OF THE FIFTY YEARS 1841 TO 1890." By WILLIAM ELLIS, F.R.S., F.R.Met.Soc. (p. 169).

"ATMOSPHERIC DUST OBSERVATIONS FROM VARIOUS PARTS OF THE WORLD." By E. D. FRIDLANDER, B.Sc. (p. 184).

"ANALYSIS OF THE GREENWICH RAINFALL RECORDS FROM 1879 TO 1890, WITH SPECIAL REFERENCE TO THE DECLINATION OF THE SUN AND MOON." By MAJOR H. E. RAWSON, R.E., F.R.Met.Soc. (p. 203).

CORRESPONDENCE AND NOTES.

Extraordinary High Barometer Readings.—Dr. Hann writes, with reference to Dr. Woeikof's notice of extraordinary high barometer readings at Barnaoul and Irkutsk, quoted at the end of Mr. Scott's paper (p. 157), that he himself, in the *Zeitschrift der Öst. Met. Gesellschaft*, vol. xvii. p. 96, had cited the following readings for December 16, 1877:—

Tomsk, 73·5 metres above sea-level, reduced to 0° C., 792·8 mm.
Omsk, 80·0 „ „ „ 790·1 mm.
Tomsk therefore gives 31·213 in. Omsk 31·106 in.

The Tomsk reading appears to Dr. Hann to be the highest reading *actually observed*, as the absolute level of the station has been pretty accurately determined by the Siberian Survey, and is only 73·5 metres, so that the correction for altitude is reasonably safe; accordingly the corrected reading at sea-level is 801·4 mm. or 31.55 inches.

River Bars and Ocean Currents.—I would beg to report on the above subject to your valuable Society, for the purpose of obtaining any advice and assistance in furthering what I trust may prove of practical advantage.

The Buffalo River.—Ten years' acquaintance of our Bar has led me to deduce a theory as to the principal causes of the deposits and dispersion of the sand at the river entrance, for this sand, as in many other rivers, proves a serious obstacle in its development. At certain seasons of the year, changes may be expected in the depth of the water, and direction of the fairway or channels; thus, from the spring to the autumnal equinox, a straighter and deeper channel is anticipated, while during the winter months the shoaling generally spreads out with a more easterly channel. Drift currents seem to make no perceptible alteration in the Bar, even combined with gales of wind and heavy south-west seas.

Ocean Littoral Currents.—The Tropical or Agulhas current is the surface and prevailing one, the maximum temperature in the roadstead is found to be 79° during summer months, but slightly colder nearer shore. In the winter this current is about 65°, and occasionally we find it 6° or 7° warmer at the bottom. Matter in suspension can be traced at times by filling a bottle with water, and after settling, about a grain has been found.

The Polar or Antarctic current, termed an inshore current, is of the greatest interest. It is more rarely found during the winter, but it appears during the summer, or from spring to autumn, with a minimum temperature of 53°. A difference of 20° in temperature in the roadstead has been found between the surface and bottom in ten fathoms of water, say from 76° to 56°. When there is this marked difference in the temperatures, there are signs of unusual disturbance on the sandy portions of the coast-line and river Bar, the surf having then much sand in suspension, but at other times with a normal temperature above and below, the heavy breakers on the beach are apparently free from sand.

A "Black" South-easter, a gale accompanied with thick misty rain, has great effect in dispersing the sand and deepening the channel, the wind veering from South-west to South-east with a cross sea. At the time a colder change of sea temperature is found, decidedly favouring the theory that the colder current on the bottom acts as a strong scour in active opposition to the warmer current.

Bar Improvement.—I have found that a vivid display of lightning on the south and south-west horizon behind a low bank of heavy cumulus often gives evidence of an approach of the colder or Antarctic current. The coast-line gives evidence that the colder current scours and prevents sand deposits, for all exposed headlands and reefs are clear of sand on the southern side, while a sandy deposit is found on the northern side, or where it comes out of the influence of this Antarctic current. I have used the deep-sea thermometer since January 1894, and have taken nearly one thousand temperatures of both surface and sea bottom, and am convinced that very interesting and practical information can be obtained from it, combined with the hydrometer and other instruments. I have failed to discover any difference in the specific gravity of these currents by the common hydrometer I am using, excepting in the river, where the indications have been very satisfactory. Any correspondence on this question would be gladly accepted from you.—A. E. PAKEMAN, Master Mariner, Coast Mail Packets Co., East London, Cape Colony, April 17, 1896.

Specific Gravities and Oceanic Circulation.—Dr. Buchan in his Report on Oceanic Circulation, which was based mostly on the observations made on

board H.M.S. *Challenger*, gave a chart in which the specific gravities dealt with were all at the standard temperature of 60°, the standard density being that of distilled water at 39°·2. By this method of treatment the question of the salinity of the water is approximately shown, which is one of the most important factors in the physics of the ocean. The movement of the water, however, depends on the specific gravity at the temperature observed; and Dr. Buchan has dealt with this in a paper in the *Transactions of the Royal Society of Edinburgh*, vol. xxxviii. part ii. His conclusions are as follows:—

The prevailing winds, in their direct and indirect effects, are the most powerful agents concerned in oceanic circulation. They originate and maintain the surface currents of the ocean, and the influence of these currents is, through friction, felt to a depth of probably several hundred fathoms. In intertropical regions the prevailing Trade winds drive the surface currents westward to the eastern shores of the continents, and there, accordingly, a greater depth of warm water is found occupying the upper layers of the ocean than elsewhere; and, except where the rainfall is abnormally heavy, this water is not only very warm, but it has acquired from evaporation a salinity much higher than the general average of the ocean. The results over the face of the ocean have been already described, and may be studied in greater detail on Map I. of the *Challenger* Report. It is one of the most remarkable results of this inquiry that these areas of high surface temperature and high salinity are found represented at all depths down to the bottom, with just a tendency to an extension of the areas with increase of depth. It follows that, waiving in the meantime what takes place at the bottom, the great mass of the ocean intermediate between the upper layers and the bottom exhibits principally vertical movements.

On the other hand, on the eastern sides of the oceans whence the Trade winds start on their course, there is an upwelling of the colder water of the greater depths towards the surface in a manner similar to what Dr. Murray has shown happens in the case of our Scottish lochs when strong winds sweep over their surfaces. In such cases the warmer surface water is blown to the leeward shores of the lochs, and colder water, by upwelling, rises to the surface on the wind-shore of the lochs. These cold areas of a lower surface temperature and salinity are also continued down to the bottom, with a tendency to an expansion of the areas with descent.

The ice-cold water which occupies the bottom of the ocean in all latitudes necessitates a constant supply of water of a very low temperature from the deep water of the Southern and the Antarctic Oceans, and in a less degree the Arctic Ocean. This slow moving current of cold water along the bottom of all parts of the ocean is effected, on the one hand, by the reduction, in the intertropical regions, of the surface waters by evaporation and by the extratropical prevailing winds blowing polewards, and on the other by the greater specific gravities of the ocean in high latitudes, and the "head" of water accumulated there by the prevailing South-westerly winds of the northern and the prevailing North-westerly winds of the southern hemisphere.

The increase of the temperature, which may be considered as setting in from 1500 fathoms upwards to the surface, implies that this excess of temperature has its origin wholly in the surface temperature. The restricted extent and continuity through all depths of these two contrasted areas may be regarded as the balance struck by the forces which produce the upward movement, in lifting the cold water of great depths towards the surface, and the downward movement of transferring the surface warmth to greater depths. The result would have been materially different if the depth of the ocean with respect to its extent had not been so insignificant as it is. But additional experiments on a large scale, and observations, are needed before these upward and downward movements in the ocean, which are conducted on so vast a scale,

can be explained, or even adequately described, as to the way in which they are effected.

There are subsidiary causes powerfully influencing oceanic circulation, the chief of which are abnormally heavy rainfall, such as occurs in the west of the Pacific: undercurrents of a high temperature and specific gravity from the Mediterranean and Red Seas; the causes leading to the extensive upwelling seen in the Pacific to the south-east of the Sandwich Isles, and analogous positions in the Atlantic and Indian oceans, which are closely connected with the supply of a portion of the water of the great surface currents of these oceans; and the intertropical position of the line of lowest mean barometric pressure, resulting in a temperature much higher in the North than in the South Atlantic, and much higher in the South than in the North Pacific Ocean.

Types of Australian Weather.—In continuation of the valuable work on Australian Meteorology which the Hon. Ralph Abercromby initiated in December 1892, by offering a money prize for the best essay on Southerly Bursters, he has recently selected the phases of Australian Weather, which have been treated in a paper by Mr. H. A. Hunt, the second Meteorological Assistant at the Sydney Observatory. Many of the types appear to be peculiar to Australia, and, at the same time, connected with equatorial and other weather. They throw much new light upon the source of the greater part of Australian rain, and show how these rain storms develop out of ordinary weather conditions. They also form an important contribution to the study of weather in the southern hemisphere generally.

As a general rule, weather is set fine when anticyclones move rapidly, and in a straight line across Australia, *i.e.* at a rate exceeding 500 miles a day; and the weather is unsettled when they move slowly, and not in a straight line, but in a zig-zag course, especially if they show no appreciable forward motion for a day or two. When anticyclones move in low latitudes the conditions favour dry weather; but in high latitudes, wet weather, especially if they rest for a time south of South Australia.

Mr. Hunt has given twenty types of Australian weather, each of which he has illustrated with copies of the Sydney Weather Charts. The following is the list of types:—(1) Moving Anticyclones; (2) Monsoonal Rain Storm; (3) Development of a Cyclonic Storm in low latitudes from a Monsoonal Depression; (4) Development of a Cyclonic Storm in high latitudes from a Monsoonal Depression; (5) Conditions favourable for Thunderstorms; (6) Cyclonic Thunderstorms; (7) Vertical and nearly straight Isobars; (8) Cyclones from North-west; (9) Cyclones from North-east; (10) Tornadoes; (11) South-east Gales; (12) Development of Cyclones from a ∧ Depression; (13) Westerly Winds; (14) Southerly Bursters; (15) Black North-easter; (16) Winds blowing against Isobars; (17) Summer Anticyclone; (18) Winter Anticyclone; (19) Square-headed ∧ Depression; (20) Advent of an Antarctic Storm.

Madras Observations.—A set of Tables of Daily Meteorological Means at the Madras Observatory has just been issued by Mr. C. Michie Smith, the Government Astronomer. The accompanying table gives the monthly and annual means for several of the elements, which are based on the following year's observations:—Barometer, 50 years, 1843-92; Temperature and Cloud, 30 years, 1861-90; and Rain, 80 years, 1813-92.

Monthly and Annual Means, Madras Observatory.

hs.	Barometer reduced to Sea-level.	Dry.	Temperature. Wet.	Max.	Min.	Rel. Hum.	Amt. of Cloud.	Rain-fall.
	in.	°	°	°	°	°/o		in.
y . .	30·023	75·1	69·2	84·6	67·5	73	3·7	·89
ry . .	29·990	76·7	70·8	86·6	68·0	73	2·4	·28
. .	29·930	80·0	73·9	89·2	72·1	74	2·4	·39
. .	29·849	84·0	77·6	92·9	77·2	74	2·8	·62
. .	29·757	86·7	78·3	97·8	80·8	67	3·8	2·12
. .	29·725	86·4	76·6	98·3	80·3	62	6·4	2·11
. .	29·743	84·5	75·9	95·6	78·5	65	7·1	3·87
t . .	29·772	83·3	76·0	93·7	77·3	70	6·7	4·56
ıber .	29·801	83·0	76·3	93·2	77·1	72	6·2	4·69
r . .	29·866	80·6	75·6	89·0	75·2	78	5·9	11·00
ıber .	29·949	77·5	72·9	85·0	72·3	79	5·9	13·21
ber .	30·004	75·5	70·6	83·6	69·8	77	5·2	5·28
ear .	29·867	81·1	74·5	90·8	74·7	72	4·9	49·02

imate of Ruwenzori.—Mr. G. F. Scott Elliot, in a paper read before the Geographical Society in April 1895, on his expedition to Ruwenzori and nyika, gives the following interesting particulars of the climate, and of the on Ruwenzori:—

[found the climate of Ruwenzori a peculiarly trying one in most spots. 5000 feet one is quite as liable to fever as on the Uganda plateau, or even so. At about 7000 feet the perennially humid forests begin, and even at eight in the bottom of the valleys, *e.g.* in my camp at the Wimi valley, arcely had an hour's sunshine, and everything was permanently humid. vet condition prevails up to the height of at least 13,000 feet. Hence it y on projecting bluffs or ridges at about 6000 feet that one has at all a imate. On a few favoured spots such places are really magnificent, and ıjoys excellent health. I am bound, however, to say that I saw no spot to ıroughly recommended as a sanitarium.

The most curious feature of Ruwenzori is the white cloud which envelopes pper mountain. In the morning this cloud is at an average level of about feet, but is very much lower in the valleys, sometimes descending to 6000 It is also lower at the north and south ends of the chain, where the ain itself is not so high. The forest follows the average level of the cloud closely, descending lower in the valleys, and also to north and south in the way. It seems to me pretty clear that the moisture-laden winds, after g over the swamps of Uganda and Victoria, are intercepted by the moun- nd there condensed.

The peculiar feature of Ruwenzori, however, is the manner in which the cloud Beginning about 10 a.m. to ascend, it slowly climbs upwards all day, and ıally vanishes away about 5.30 p.m., when one gets the only chance during y of seeing the snow-peaks. This seems to me to be due to the mountain ing more rapidly heated by the sun than the plains below, leading to an d current of air. About this time (5.30) the whole mountain-side is ly heated, and this explains another curious feature of the mountain. ose valleys which lead directly to the base of the snow-peaks, *e.g.* the ku, Wimi, and Butagu, an extremely violent wind (almost a hurricane) down the mountain from about six to seven, then dying suddenly away to ıg. This is simply the cold air from the snow rushing down to the heated slopes. This wind does not occur on the evenings when there has been ın the lower parts, which is what one would expect. Sometimes at the noment there are, in an upper current of the atmosphere, clouds moving

towards the upper peaks. Of course these conditions make all kinds of work, and especially mapping, very difficult. It is almost impossible to know where one is, and it was not till I had been more than five weeks about the Yeria and Wimi valleys that I discovered that the snow-peaks lay several miles to the south-west, and much nearer the western sides of the mountain."

RECENT PUBLICATIONS.

American Meteorological Journal, Vol. XII. Nos. 9–11. January—March 1896. 8vo.

The principal articles are:—The audibility of Fog Signals: by Prof. H. A. Hazen (3 pp.).—Atmospheric phenomena in the Arctic regions in their relation to dust: by Prof. W. H. Brewer (6 pp.).—The rainfall of the Malay Archipelago: by Prof. A. Woeikof (8 pp.).—Psychrometer studies: by Prof. H. A. Hazen (5 pp.).—The diurnal oscillation of atmospheric pressure at the Peruvian stations of Harvard College Observatory: by Prof. S. J. Bailey (5 pp.).—Cyclones and anticyclones: by Prof. H. A. Hazen (16 pp.). The object of this paper is really a plea for atmospheric exploration.

Annales de l'Observatoire Météorologique de l'Université Impériale à Odessa. Par A. KLOSSOVSKY. 1895. 4to. 1896.

This work is in the Russian language, but Dr. Klossovsky has considerately published a French translation of his report, which shows that his system is very active indeed. At the close of the report he gives a sort of syllabus of the course of instruction in Meteorology which he proposes to establish at the observatory. It consists of three cycles, probably intended to fill up three terms. The scheme embraces several branches of science which are not usually classed under Meteorology, such as the rating of watches. The patterns of instruments employed at the observatory are almost exclusively continental, chiefly Russian or French.

Annuaire de la Société Météorologique de France. Tome XLIII. 1895. Avril—Juin. 4to.

The principal articles are:—Sur la plus ancienne série française d'observations thermométriques et météorologiques: par C. Maze (6 pp.).—Le premier thermomètre à mercure: par C. Maze 2 (pp.).—Les orages à Ernée depuis 20 ans: par M. Gougis (2 pp.).—Le grain à arc: par C. Labrousse (1 p.).

Aus dem Archiv der Deutschen Seewarte. XVIII Jahrgang. 1895. 4to. 1896.

The principal meteorological articles are: Oberflächentemperaturen und Strömungsverhältnisse des Aequatorialgürtels des Stillen Ozeans: von Dr. C. Puls (38 pp. and 4 plates).—Vergleichende Regenmessungen an der Deutschen Seewarte: von Dr. W. J. van Bebber (14 pp. and plate).—Die Isobarentypen des Nordatlantischen Ozeans und Westeuropas, ihre Beziehungen zur Lage und Bewegung der barometrischen Maxima und Minima: von Dr. W. J. van Bebber und Dr. W. Köppen (27 pp. and 23 plates).

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. December 1895—April 1896. 4to.

The principal articles are:—Die jährliche Periode der Stürme in Europa: von G. Hellmann (9 pp.). This is an enquiry into the annual period of storms in Europe based entirely on anemometrical results from definite stations. Dr. Hellmann laments that in many countries there are no printed anemometrical results, but he has taken the trouble of examining the *Quarterly Weather Report* for 16 years to take out the storms for Valencia, Falmouth, and Kew. He assumes different storm values for each station, viz. in miles per hour: Valencia 50, Falmouth 45, and Kew 36. He gives monthly percentages for 59 stations, and shows that over a great part of Europe storms are not most frequent in winter, as is the case in the British Isles. At San Fernando, *e.g.*, 45 per cent of the storms are in March. Several stations have a comparatively calm January, but only one, Windau, near Riga, shows an approach to the maximum at the autumn equinox. Dr. Hellmann concludes by saying that the belief in equinoctial storms is reasonably justifiable in many parts of Europe, inasmuch as the period of storms lies between the two equinoxes, beginning after the autumn and ending before the spring equinox.—Die vertikale Komponente der ablenkenden Kraft der Erdrotation in ihre Bedeutung für die Dynamik der Atmosphäre: von A. Sprung (6 pp.). This is a criticism of, and reply to, Dr. Ekholm's paper on the same subject which appeared in the *Zeitschrift* for 1894.—Temperaturbeobachtungen an der Schneedecke, während des Winters 1894-5 zu Aachen: von P. Polis (11 pp.). The author instituted a series of observations on the temperature of the snow surface at Aix-la-Chapelle in the winter of 1894-5. He summarises his results as follows:—1. The temperature of the surface is in general below that of the air, but under the surface, even at the slight depth of 5 centimetres, the reverse takes place. 2. The difference of temperature between snow and air increases with decrease of cloudiness and rise of temperature, but the amount of cloud always influences the temperature of the snow surface. 3. With snow or fog and with great humidity the snow surface is generally warmer than the air. This seems to the author to be due to the fact that an overcast sky checks radiation, while in addition the latent heat of moisture condensed by contact with the snow tends to keep up the temperature. 4. With reference to the differences between cyclonic and anticyclonic conditions the snow surface temperature may be considered as a function of the direction of the wind: East winds reduce it, West winds raise it. 5. Strong winds raise the surface temperature, calms lower it. 6. At Aix-la-Chapelle the evaporation from the snow was greater than the condensation on it. 7. The density of the snow is proportional to its conductivity for heat.—Merkwürdige Form von Hagel-Wolken: von B. Streit (1 p.). This is an account of an extraordinary cloud seen over the Alps from Venice in 1895. It is illustrated by three sketches. The remarkable feature was that out of a cumulus a cylindrical cloud rose, and out of this a second cylinder of smaller diameter. The whole thing looks like a huge wedding cake with a protuberance with three peaks at the top of all. The phenomenon preceded a terrific hailstorm in Venice.—Das meteorologische Beobachtungsnetz von Bosnien und der Hercegovina und dessen Gipfelstation auf der Bjelasnica (8 pp.). This is an account of the development of meteorology in the territory occupied by Austria in 1879. There was no attempt at observations prior to this, and the answer to every one who asked a native about the weather was that it came "as God gives it." The Duke William of Württemberg, the first military governor, began the work, and it has gradually grown until it now numbers 77 stations, of which 3 are of the first order and one a mountain station on Bjelasnica over 6000 feet high. The greatest credit is due to the Austrians for their zeal in organising this system.—Das Klima Centralasiens nach den Beobachtungen von

Prschewalsky : von A. Woeikof (2 pp.). This is a summary of the author's paper, originally published in Russian, on the information as to the climate of Central Asia which is supplied by the four expeditions of the famous Russian traveller. Unfortunately no spirit thermometers were taken, and in each winter a few days' observations were lost, as the mercury was frozen. The means are, of course, mainly guesses, as the expeditions were continually on the march, and changes of level, etc., at the stations were constant. Among the most interesting facts are those relating to the extension of the rains of the South-west Monsoon into Thibet, and even farther.—Resultate meteorologischer Beobachtungen zu Boroma in Südafrika : von J. Fenyi, S.J. (9 pp.). The R. C. mission station of Boroma lies about 10 miles north-west from Tete on the Zambesi in 16° S. lat., and so is not very far from Blantyre. It has been provided with an outfit, which, however, did not include a mercurial barometer, owing to the difficulties of transport. The barometer observations were therefore taken by a Richard barograph with hypsometers to check it. The observations have, however, been very carefully carried out, the hours being 7 a.m., 2 p.m., and 9 p.m., and these were kept as punctually as was possible. Father Fenyi has discussed them very thoroughly. One remarkable phenological phenomenon is noticed, that several trees blossom and bear fruit during the dry season. The observer specially notes this, and says that the earth, even at shallow depths, is always damp and is very warm. The diurnal range of the barometer is remarkably uniform and constant, and is not affected by rain or even thunderstorms.—Ueber die Einwirkung der vertikalen Komponente der Ablenkenden Kraft der Erdrotation auf die Luftbewegung : von Dr. N. Ekholm (8 pp.). This is an answer to a paper by Dr. Sprung which appeared in the *Zeitschrift* for 1895.—Der Thalwind des Oberengadin : von Dr. R. Billwiller (10 pp.). This is an abstract of a paper by the author in the *Annalen* of the Central Meteorological Office of Switzerland for 1893. It is a further development of a paper on the same subject by the same author in the *Zeitschrift* for 1880, which was noticed at the time in the *Quarterly Journal*, vol. vi. The recent investigations have been carried on by means of two large scale Richard barographs, of which one was at the Maloja itself, and the other at Bevers, distant 14 miles from, and 328 feet lower than, the Maloja, the top of the pass. The local wind blows down the valley, instead of up it, and therefore in a direction contrary to that of most valley winds. Dr. Billwiller attributes this peculiar motion to the circumstance that the air over the plain of Italy is expanded by heat, and produces an excess of pressure at the Maloja, over that at Bevers, thus generating the current.

Proceedings of the Royal Institution of Great Britain. Vol. XIV. Part III. No. 89. 1896. 8vo.

This contains a full abstract of two lectures, bearing upon meteorology, delivered at the Royal Institution during the session of 1895, viz. Atmospheric Electricity : by Prof. A. Schuster, F.R.S. (17 pp.) ; and Phénomènes physiques des hautes régions de l'atmosphère : by Prof. Alfred Cornu, F.R.S. (11 pp.).

Symons's Monthly Meteorological Magazine. February—June 1896. 8vo.

The principal articles are : The high pressure in January (2 pp.).—Violent lightning stroke in South Devon (1 p.).—Extreme heat in Australia in January 1896 (5 pp.).—The American Meteorological Journal (2 pp.).—The worst gale of the 19th century in the English Midlands (14 pp.). This storm crossed the country from South Wales to Lincolnshire between 11 a.m. and 4 p.m. on Sunday, March 24, 1895, travelling at the rate of 58 miles an hour.—Fog, Mist, Haze (2 pp.).

QUARTERLY JOURNAL

OF THE

ROYAL METEOROLOGICAL SOCIETY

VOL. XXII.] OCTOBER 1896 [No. 100.

THE EXPOSURE OF ANEMOMETERS.

By RICHARD H. CURTIS, F.R.Met.Soc.

[Read May 20, 1896.]

THE proper exposure of anemometers is a subject of great importance to which but little attention has hitherto been paid. The practice has generally been to erect such an instrument on the roof of an observatory, without giving special consideration to the suitability of the building for the purpose, or to the effect it would be likely to produce upon the wind currents, and through them upon the records of the anemometer.

It only requires, however, a moment's consideration of the subject, to see that a house, of even moderate size, can hardly fail to produce a considerable effect upon a stream of air, moving at the speed of a moderate wind. Such a stream would have its motion arrested, and would to a greater or less extent, dependent upon the shape and size of the house, be deflected upwards, and thrown over the top of the building. The height to which this deflected current would rise would obviously depend largely upon the strength of the wind; and unless the cups, or plate, or vane, be placed sufficiently above the roof as to be clear of the disturbance thus caused, the record obtained from the instrument must necessarily be prejudicially affected by it.

It is an unfortunate circumstance that the neglect of this consideration in the erection of anemometers has, in some cases, introduced an element of doubt into long series of observations, obtained at the cost of much labour, time, and money.

This statement is supported by a note on the exposure of the Robinson Anemometer at Holyhead, which appeared in the Report of the Meteorological Office for last year,[1] in which attention is called to some peculiar results obtained from a comparison of the records of that

[1] *Report of the Meteorological Council for the year ending March* 31, 1895, Note C. p. 29.

instrument with those of Sir G. G. Stokes' "Bridled" Anemometer, erected a short distance away. These results bring out very clearly the effect produced upon the anemometer by the buildings which immediately surround it.

Since that note was prepared the "Bridled" anemometer has been removed to a much better site, although in its new position it is not many yards more remote from the Robinson instrument than it was before; and at the same time there has been set up by its side one of Mr. Dines' new Pressure Tube anemometers.

There are therefore at this moment three anemometers at Holyhead,

FIG. 1.—View of the Lighthouse and Railway Sheds from Salt Island, looking South-east (Low water, spring tide).

working under conditions which allow of a direct comparison being made between their indications; and as such a comparison has been carried on continuously since the beginning of October 1895, I have been allowed, by the kindness of the Meteorological Council, to bring the results before the Society.

Before doing so, however, it is necessary that I should explain in some detail the positions of the instruments.

The old harbour at Holyhead is formed by a stone pier, which extends from west to east for a distance of about 360 yards, and is then continued for a further distance of 170 yards by a close-piled wooden jetty, which, however, takes a direction slightly to the northward of east. The southern face of the pier is vertical, but on the northern side it has a ramp, sloping down to the sea at an angle of about 16°. At the eastern end of the pier, where it is joined by the jetty, there stands a circular stone lighthouse, on the top of the disused lantern of which the cups of the Robinson

Anemometer are placed, the recording apparatus being inside the lantern; the roof is curved, and the cups are about 5 feet above its apex, and 53 feet above the floor of the pier. Immediately at the base of the tower, and extending for about 100 yards to the eastward and 150 yards to the westward, are railway sheds, the pier being the point of departure and arrival of the Irish mail steamers. These sheds are open at the western and eastern ends, and along their southern front, but are closed on the northern side. The roofs are not uniform in height or shape; from the tower eastwards a girder roof is used, whilst from the same point westwards there are two ridge roofs, one of which is slightly higher than

FIG. 2.—View of Salt Island from the gallery of the Lighthouse, looking North-west (Low water, spring tide).

the other. Speaking generally, the cups of the anemometer are 30 feet above the roofs.

The floor of the pier is $14\frac{1}{2}$ feet above mean sea-level; but on the north the slope is carried up about 10 feet higher, and near the lighthouse it is further surmounted by a low wall, the top of which is about 15 feet above the general level of the pier.

At the western end, just at the commencement of the pier, there runs out to the northward, and therefore at a right angle to the pier, an embankment known as Salt Island, which forms the eastern boundary of the Harbour of Refuge. There are a few buildings at the southern end of the island, close to the pier, but they are low and detached; and the island may be described as an open stretch of grass, about 16 feet above mean sea-level, and extending for about 550 yards to the north of the pier. It is on the extreme northern point of this island that the "Bridled" and "Tube" anemometers are now placed, and in this position they have

a perfectly free exposure in all directions; the cups of the bridled instrument are now 21 feet above the ground, whilst the vane of the tube instrument is 44 feet high. From the spot occupied by these instruments the old lighthouse is distant 625 yards to the south-east by south.

Apart from the structures immediately surrounding the lighthouse the general exposure of all the instruments is good. To the southward the country, though undulating, has no important hills; and the town of Holyhead to the south-west is not sufficiently near, nor are the buildings of sufficient size, to produce much effect upon the instruments; to the west is Holyhead Mountain, an isolated hill 709 feet high, but about $2\frac{1}{2}$ miles distant; and from thence, through north round to south-east, there may be said to be a sea horizon.

Two sets of comparisons have been made—one between the records of the "Tube" and "Bridled," and the other between the "Tube" and "Robinson," anemometers.

As regards the first of these it will be sufficient to say here that it has revealed what appears to be an error either in the scale-value, or in the zero-value of the scale (or perhaps in both) of the "Bridled" instrument; and assuming the "Tube" record to be correct, as I think we may safely do, the values hitherto obtained from the "Bridled" instrument are apparently from 6·5 to 9 miles too high. In the note already referred to, one of the conclusions arrived at, upon the assumption that the "Bridled" anemometer gave the true velocity, was that the Robinson record was always too low; but in the light of the results now obtained it is clear that this statement requires some modification. The change in the site of the former instrument must also be borne in mind when comparing the figures used in the first comparison with those obtained since the change was made.

The results of the direct comparison between the "Tube" and Robinson anemometers are, however, of more general interest.

The Robinson instrument is of the "Kew pattern," *i.e.* it has cups of 9 inches diameter, and the distance from the centre of the cup to the spindle is 2 feet; the scale of the instrument is based on the usual factor (3).

The method followed in making the comparison was to take the run of the cups in sixty consecutive minutes, and to correct it to the equivalent value, using the factor (2·2) instead of (3). The *mean* value for the corresponding interval as given by the "Tube" instrument, was then taken by estimation from the record, and the difference between the two obtained. I may remark here, that although the mean value of the 'Tube" record was got by estimation, it has been found that with a little practice this can be done with a close approach to accuracy, and the difference between the values for a given hour, obtained by independent tabulators, seldom exceeds ± 1 mile.

The values were then arranged according to the direction of the wind under eight points, and afterwards the observations under each direction were grouped according to the velocity in 10-mile groups; *e.g.* all the observations of wind from North in which the force ranged from 26 to 35 miles per hour, as shown by the Robinson instrument, were put together, and the mean difference between the records of the two instruments obtained; and similarly for each of the other seven points. No observa-

tion in which the force was less than 11 miles per hour was used, and the lowest group included all velocities from 11 to 25 miles per hour.

The results are best shown by Table I., in which the mean differences under each grouping are given, together with the number of observations from which they were obtained.

Taking first the means of all the observations under each point, irrespective of velocity, it will be seen that when the wind blows from North, South-east, and South, the record of the Robinson instrument is *greater* than that of the "Tube" instrument; whilst with winds from East, South-west, West, and North-west, it is *less;* with a North-east wind, however, the record by both instruments is the same.

If in the next place we examine the groupings under velocities, it will be noticed that generally the amount of the difference varies directly with the force of the wind, but to this rule South-west winds offer a marked exception.

A satisfactory explanation of these facts is, I believe, afforded by the description of the site of the Robinson anemometer already given. It will be remembered that on the northern side the sheds are closed, and these, together with the face of the pier, present a considerable obstacle to a wind striking normally against them. The result is, that the horizontal motion of the wind is arrested, and a stream of air is thrown up above the buildings, where, at a certain point, there will be an *excess* of wind, caused by the deflected current meeting and mingling with the stream of air proper to that level. The height to which the deflected current will rise depends no doubt upon the strength of the wind; quite near the roof I should expect to find less than the proper force of wind, whilst at a height above it of probably 40 feet, or less, the current will be normal again; but it is evident that in this instance the cups 30 feet above the roof are well within the disturbed area.

The same reasoning will explain the excess experienced with South-east and South winds; for although these blow into the open front of the sheds, yet there is no egress for the air at the back. The sheds therefore become filled with air, compressed by the force of the wind; and the result produced is similar to that caused by the wind striking against the closed northern side—the air current is forced to rise, and flows over above the roof.

When, however, the wind blows in the direction of the *length* of the sheds the result is very different. Now the sheds act as a large conduit, into which the air is sucked, and drawn down from above; with the result that *less* than the normal amount of wind reaches the cups, and their record is therefore too small. This effect is most marked when the wind is from the West, because one opening into the sheds is almost immediately under the tower; before reaching which the wind has to pass for many yards along a narrow gully, formed by the wall of one of the sheds on the one hand, and by the sea-wall, which rises above the floor of the pier, on the other.

A North-east wind, however, is free from both of these disturbing influences, since it strikes the closed northern side obliquely, and glancing off it flows past without being thrown upwards, at any rate to an appreciable extent.

I have already said that for making this comparison the winds were

TABLE I. Showing the Difference between the Records of the Robinson and the Pressure Tube Anemometers under each of Eight Points, and at various Mean Velocities.

Velocity Limits, under which Observations are Grouped.	No. of Obs.	Mean Velocity by Robinson.	Mean Velocity by P. Tube.	Diff. in Miles R.-P.T.	Per Cent of Diff. to Mean by P.T.	No. of Obs.	Mean Velocity by Robinson.	Mean Velocity by P. Tube.	Diff. in Miles R.-P.T.	Per Cent of Diff. to Mean by P.T.	No. of Obs.	Mean Velocity by Robinson.	Mean Velocity by P. Tube.	Diff. in Miles R.-P.T.	Per Cent of Diff. to Mean by P.T.	No. of Obs.	Mean Velocity by Robinson.	Mean Velocity by P. Tube.	Diff. in Miles R.-P.T.	Per Cent of Diff. to Mean by P.T.
		NORTH.					NORTH-EAST.					EAST.					SOUTH-EAST.			
Miles					%					%					%					%
11-25	198	17·5	15·7	+ 1·8	11·5	143	17·1	17·4	- 0·3	1·7	229	17·2	19·2	- 2·0	10·4	72	16·9	16·1	+ 0·8	5·0
26-35	59	30·6	26·8	+ 3·8	14·2	61	29·6	28·9	+ 0·7	2·4	56	30·1	33·8	- 3·7	11·0	10	28·9	25·3	+ 3·6	14·2
36-45	6	37·7	32·5	+ 5·2	16·0	...	...	...	...	...	15	37·7	41·7	- 4·0	9·6	7	40·0	35·7	+ 4·7	13·3
46-55	1	47·0	41·0	+ 6·0	14·6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
All velocities	264	21·0	18·7	+ 2·3	12·3	204	20·9	20·8	+ 0·1	0·5	300	20·6	23·0	- 2·4	10·4	89	20·0	18·6	+ 1·4	7·5
		SOUTH.					SOUTH-WEST.					WEST.					NORTH-WEST.			
Miles					%					%					%					%
11-25	394	18·2	16·3	+ 1·9	11·7	621	17·1	19·0	- 1·9	10·0	464	16·7	22·0	- 5·3	24·1	302	17·1	18·6	- 1·5	8·1
26-35	107	30·0	25·6	+ 4·4	17·2	99	29·3	30·1	- 0·8	2·7	90	29·7	37·5	- 7·8	20·8	122	30·2	31·6	- 1·4	4·4
36-45	17	38·8	32·8	+ 6·0	18·3	4	38·8	39·8	- 1·0	2·5	13	37·1	44·5	- 7·4	16·6	23	38·3	39·6	- 1·3	3·3
46-55	4	49·8	43·0	+ 6·8	15·8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
All velocities	522	21·5	19·0	+ 2·5	13·2	724	18·9	20·6	- 1·7	8·3	567	19·3	25·0	- 5·7	22·8	447	21·8	23·2	- 1·4	6·0

grouped under eight points, and consequently a fair distribution had to be made of all winds from intermediate points; *e.g.* the observations under East include all those from East by North and from East by South, together with one half of those from East-north-east and from East-south-east; the remaining observations from the latter two points being placed under North-east and South-east respectively. It would, no doubt, have been better to have grouped the observations under sixteen points, because it is clear that the values given are in some cases too high, and in others too low, owing to the inclusion of these intermediate points. For example: Table I. shows that with South winds, whose velocity is between 11 and 25 miles per hour, and in which the intermediate points are included, the Robinson instrument gives an excess of 11·7 per cent; but

FIG. 3.—View of the Lighthouse from the Pier, looking East.

taking forty observations of winds from South only, but of the same force, we get an excess of 17·7 per cent. The former result is without doubt influenced by the winds from South-south-west included in it, and at that point there would appear, from Table II., to be a balance between what may be called the negative and the positive influence of the sheds.

But in order to bring out clearly the effect of this grouping I have prepared Table II., which shows the differences yielded by about forty observations at each of the sixteen points, without including any from intermediate points. The observations have been taken as they came, without any attempt at selection; but under some points, where the total number of observations is small, so many as forty observations were not available.

The very regular progression as we proceed round the compass, which

is shown here by the differences when expressed as percentages of the mean velocities, at once negatives the idea that they are at all fortuitous in character.

TABLE II.—MEAN DIFFERENCE BETWEEN THE ROBINSON AND THE PRESSURE TUBE ANEMOMETERS, SHOWN BY (ABOUT) FORTY OBSERVATIONS OF VELOCITY BETWEEN 11 AND 25 MILES, FROM EACH OF SIXTEEN POINTS :—

Direction of Wind.	Number of Observations.	Mean Velocity by		Diff. in Miles (R.-P. T.)	Percentage of Diff. to Mean by P. Tube.
		Robinson.	P. Tube.		
					%
North	40	18·2	16·5	+1·7	+10·3
* NNE	37	15·4	14·4	+1·0	+ 6·9
* NE	23	19·2	18·5	+0·7	+ 3·8
ENE	40	18·0	20·0	-2·0	-10·0
East	40	17·7	20·3	-2·6	-12·8
* ESE	21	15·5	16·6	-1·1	- 6·6
* SE	18	15·2	13·7	+1·5	+10·9
* SSE	18	21·2	17·4	+3·8	+21·8
South	40	18·6	15·8	+2·8	+17·7
SSW	40	16·5	16·4	+0·1	+ 0·6
SW	40	19·4	22·3	-2·9	-13·0
WSW	40	17·5	24·2	-6·7	-27·7
West	40	16·6	22·2	-5·6	-25·2
WNW	40	17·4	21·0	-3·6	-17·1
NW	40	18·4	19·0	-0·6	- 3·2
NNW	40	18·0	16·4	+1·6	+ 9·8

* For these points so many as forty observations were not available.

Beginning with North the table shows at that point an excess of the Robinson record over that of the Pressure Tube of 10 per cent, which, however, steadily decreases as we proceed Eastward. At North-east it is but 4 per cent, and just after passing that point the two records would evidently agree, for at East-north-east the excess has become changed into a defect of 10 per cent, which increases to 13 per cent at East. From this point the negative difference, in its turn, decreases, and an agreement between the two records is again reached at about South-east-by-east. At South-east there is once more an excess of 11 per cent, which increases to a maximum of 22 per cent at South-south-east, this being the largest excess shown under any point. At South the excess is 18 per cent, but it then diminishes rapidly, and at South-south-west the two instruments are for a third time together. Under South-west we have once more a negative difference of 13 per cent, and at the next point, West-south-west, we find the maximum defect, amounting to 28 per cent. West shows a slight falling off, but from that point the negative error rapidly lessens as we proceed towards North. At North-west it has almost disappeared, and at North-north-west we again find an excess of 10 per cent, the amount with which we started at North.

To revert again to Table I. it will be noticed that generally an increase is shown in the amount of difference, whether *plus* or *minus*, with an increase in the force of the wind; and the exceptions to this rule are, I believe, largely due to the inclusion of the intermediate points just referred to. South-west is, however, an exception which cannot be accounted for in this way. Taking all the observations of due South-

west winds, under the first two groups, I got for velocity 11 to 25 miles a mean difference of $-2 \cdot 5$ miles, and for velocity 26 to 35 miles $-0 \cdot 2$ miles, which is substantially the same as in the table.

An explanation of this decrease in the difference between the two instruments at this point, with an increase of velocity, is, however, suggested by a study of the plan of the pier, which shows that for some yards to the westward of the lighthouse it has been widened, by a staging built out in front, over the water; and the western ends of the sheds which cover this addition are wholly or partially closed. It would seem that with the stronger winds these closed ends produce an appreciable deflecting effect upon the air current, in opposition to the conduit action of the sheds themselves, which action may be further diminished at such times by the air finding a difficulty in escaping from them, as is certainly the case when the wind blows more from the Southward. On the other hand, the decrease in the mean difference under West for velocity 36 to 45 miles is explained by the fact that all the observations in that group were actually from points to the North of West; there are but thirteen observations in all, nine being from West by North with a mean difference of 7·75 miles, and four from West-north-west with a difference of 7·5 miles.

That such a deflection of the wind as I have indicated really takes place under conditions corresponding to those presented by these sheds, I have proved on many occasions, and in several ways, two of which I may mention.

I am acquainted with a nearly perpendicular cliff, on the edge of which I have stationed myself when the wind has been blowing strongly against its face. By means of a simple appliance I have projected pieces of paper over the front of the cliff, and liberated them at varying distances, up to about 3 feet from the edge. On being released the papers were always carried up vertically for some feet above the top of the cliff. If, however, the sheet was liberated close to the edge, its upward movement soon ceased, at a height of perhaps 10 feet or so, and it would then be borne slowly inland, and fall to the ground some yards in my rear; from this point it would make its way back towards where I stood, and in this way I have several times used the same sheet more than once. On the other hand, if the release took place farther out, the paper would be taken somewhat higher up, and then be carried inland so swiftly that in a second or two it would be out of sight. From this it is evident that an eddy was formed somewhat like that shown in the sketch (Fig. 4, p. 246).

On another occasion I was caught in an exceptionally heavy squall of wind and rain from the westward, when on a moor which lies to the rear of the Rhosilly Mountain, in South Wales. This hill forms a long ridge, with an extremely steep escarpment to the westward, facing Tenby Bay, whilst to the east it falls away much more gradually in the moor, upon which I was. With difficulty I made my way up the hill to the ridge, against the wind and rain, the gusts being at times so strong that I could scarcely stand against them, but on reaching the top I found myself in comparatively quiet weather, and the ground scarcely wetted, although the squall had not by any means passed away. Here a similar deflection was in progress to that which was observed at the cliff, and the exceptional strength of the gusts I experienced was due to the downrush

of the air, which had first been thrown upwards by the face of the hill.

In both these cases we have examples of what I believe occurs, on a smaller scale, when the wind strikes the northern face of the pier.

The conclusion of the whole matter is: that for anemometrical records to be reliable, and of value, not only must the instrument be exposed in an open place, free from local obstructions, but it is also absolutely essential that the stand which carries it shall offer practically no resistance to the wind; it is undesirable, not to use a stronger term,

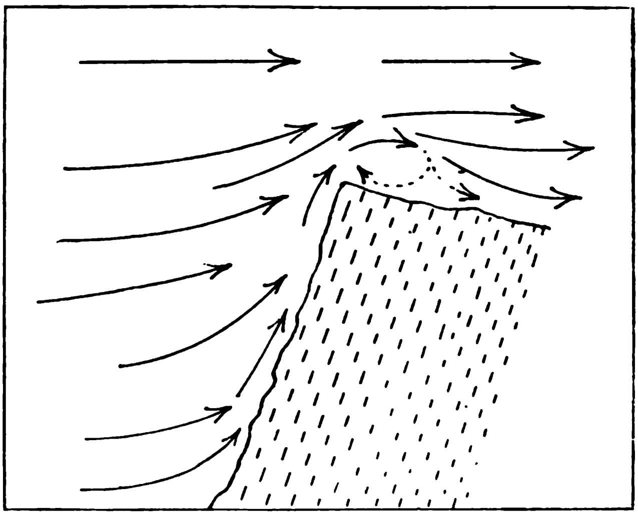


FIG. 4.—Sketch showing deflection of the wind caused by perpendicular cliff.

that the "stand" should be formed by a house, no matter what its shape or size, unless the cups can be placed farther above the roof than is generally found to be possible. I believe that a suitable open structure, with a hut for the recording apparatus, could generally be erected at no great cost, wherever a Robinson, or a pressure plate, instrument is required; but one of the great advantages offered by the Dines' "Tube" instrument is the facility with which the vane can be placed in a satisfactory position, without the restraints necessarily imposed by the connecting shafts of other forms of registering anemometer.

In conclusion, I should like to express my thanks to Mr. C. H. Thompson and Mr. L. Powers, of the Meteorological Office, for much valuable assistance rendered in the preparation of the data upon which this paper is based.

DISCUSSION.

The President (Mr. E. MAWLEY) said that the thanks of the Society were due to Mr. Curtis for his most suggestive paper. The author had certainly placed anemometry in this country in a very bad light, for comparatively few anemometers had even as good an exposure as the one at Holyhead, the position

of which he had so strongly condemned. In the last paragraph of the paper there, however, occurred a reference to the Dines anemometer which was very encouraging, as it showed that we now possess a high-class instrument, the combined vane and tube of which could easily be placed high enough above the roof of almost any building to be beyond the reach of disturbing currents. The general adoption of this form of anemometer would be an important step in the direction of uniformity of exposure, but there would still remain the difficulty of placing the instruments at the same height above the ground. He was, however, pleased to announce that the Council had under consideration a proposal to carry out some experiments with a view to ascertain the relative strength of the wind at different heights. Should these prove successful, it would then be possible to apply corrections for elevation. So that the outlook as regards the indications of anemometers in the future was, after all, never more hopeful.

Mr. F. Gaster said that some years ago he had been asked by Mr. Scott to make a comparison of the records from certain anemometers with the force of wind as estimated by the observers at the same stations. He did so both for Holyhead and Yarmouth. At Yarmouth some remarkable differences were found. The town lies to the west of the anemometer, and on the east is the sea, and the anemometer gave the velocity of Westerly winds so entirely different to those from the Eastward that those for the Westerly winds had to be omitted in endeavouring to form a scale of velocity for use in the Meteorological Office. On consulting the log of the St. Nicholas Gat light-vessel, which lay off Yarmouth, and of course had an unquestionable exposure, the results were confirmed ; and it was evident that the Westerly winds had not reached the anemometer on shore with much more than half the strength of those experienced from the Eastward because of their being intercepted by the houses of the town. Many anemometrical records were absolutely unreliable. A good exposure was essential, a bad one being worse than none at all, because it was misleading. He thought the last sentence in Mr. Curtis's paper was an excellent one with regard to exposure. With reference to the anemometrical records at high-level observatories, in his opinion the contour of the country affecting the air currents rendered them practically useless.

Mr. W. H. Dines said that he thought they must all feel greatly indebted to Mr. Curtis for his paper. There was only one point in it with which he did not entirely agree, and that was the distinction drawn between light and strong winds. He thought that if the house or building on which an anemometer was placed influenced it for one kind of wind, it would do so, when taken as a percentage error, equally for any other strength of wind. It seemed to be well established that the tube anemometer agreed with the Kew pattern Robinson with a factor 2·2, and this being so, Mr. Curtis had proved that the sheds at Holyhead increased the registration of certain winds from 20 to 30 per cent. He had recently made a few experiments on exposure himself. He had erected three anemometers on an ordinary dwelling-house about 40 feet square. The highest was 39 feet from the roof and 72 feet from the ground ; the second 18 feet above the roof, and the third 9 feet. The results were as follows :—Taking the highest as a standard, with winds for which he had a good exposure, *i.e.* winds from a direction in which, standing on the roof, he could see several miles, the 18 feet anemometer registered 90 per cent, and the 9 feet registered 80 per cent. With directions in which there were trees higher than the house within a few hundred yards, these percentages reduced to 80 and 70. The percentages seemed to be entirely independent of the force of the wind. The 18 feet anemometer was apparently uninfluenced by the gables and chimney-stacks of the house, but the 9 feet anemometer was undoubtedly greatly influenced by them. It was noteworthy that no single observation had ever given a higher reading from a lower anemometer.

Mr. C. HARDING said that he regarded the question of anemometry as being in a very unsatisfactory condition. Mr. Gaster had referred to the Westerly winds at Yarmouth only registering about one-half their normal velocity, which he thought would be the natural result after passing over the whole town. But did this sufficiently account for the difference? The anemometer was on the top of the Sailor's Home (which was one of the largest houses in the town) and a very few feet from the top. The building was on the sea front facing east, and with this exposure the Easterly winds would be open to doubt. He also mentioned the interesting comparisons made by Mr. Chatterton of the recording anemometers at the different observatories, with the observations made on light-houses and light-vessels (printed in the *Quarterly Journal*, vol. xiii. p. 215), and which gave different results to those published by the Meteorological Office. He thought the present paper was of the highest possible value, and he thoroughly agreed with Mr. Curtis's method of work. It was very unsatisfactory at an observatory like Holyhead, admittedly among the best for anemometer exposure, to find an error of 50 per cent ranging over the 8 points between south and west. The paper had explained something which had puzzled him very much at the time, viz. the great difference between the Fleetwood, Liverpool, and Holyhead instruments in the great gale of December 1894, when the anemometer at Fleetwood had registered 107 miles an hour, the velocities at the two other places being 89 and 71 respectively. Possibly exposure was a large factor in this difference.

Mr. G. J. SYMONS said that in the year 1862, when an assistant in the Meteorological Office under Admiral FitzRoy, it was his duty to superintend the erection of an anemometer in the Orkney Islands. He had instructions to place it on the Manse, a square building on a little eminence. Dr. Clouston objected to the instrument being placed there, and he (Mr. Symons) was inwardly pleased, as he had never been favourable to the erection of anemometers on high buildings. Dr. Clouston's objections took two forms: (1) that an anemometer on a roof must record an excess, because the air which could not pass through the building must pass by the sides and over the top, where therefore the record would be in excess; and (2) that the heritors would not allow the safety of the roof to be jeopardised by the erection thereon of the anemometer. Mr. Symons finally built a small pyramid of timber and placed the anemometer on the top of it.

Mr. Symons distributed copies of a diagram (printed in *British Rainfall*, 1871) by the Rev. F. W. Stow, "showing the probable effect of non-horizontal wind currents in distributing the fall of rain on the ground irregularly," illustrating the effect of buildings, trees, etc., on wind velocity.

Admiral J. P. MACLEAR inquired what height an anemometer would have to be to get a reliable record. In the case of Holyhead it was 30 feet above the sheds, and Mr. Dines's instrument was 18 feet above the roof.

Mr. T. W. BAKER thought that the discussion had come at a most opportune time, as any points raised might be introduced at the International Meteorological Conference to be held at Paris in September this year, by Mr. Scott, if he attends the meeting. He was sorry Mr. Curtis had not got a photograph showing the position of the anemometer at Deerness, Orkneys, which in his opinion was an ideal exposure. The cups were 17 feet above the ground, and there were no trees, hills, etc., to in any way affect the records. At Fleetwood also the anemometer had an excellent exposure. It was fairly easy to discover a good position for a rain gauge, but with an anemometer it was vastly different and decidedly more difficult.

Dr. H. R. MILL showed in the lantern a diagram made in the lecture-hall illustrating the effect of a strong wind blowing "onshore" on Loch Lomond, where the hillside was high and remarkably steep. The wind striking the face of the hill was deflected backward with enough strength to neutralise its own

direct effect on the water, the contact of the two currents causing a condition of calm so that a small boat could be rowed with safety during a gale. Opposite a lateral valley, however, the full force of the gale was experienced on the lake, and the water could be seen lashed into foam by the wind. This showed the powerful effect of local geographical conditions on wind force, and the necessity of caution in treating anemometer results in mountainous districts, and it also enforced the necessity of care in choosing an exposure.

Mr. H. SOUTHALL said his first experience of anemometers was in a storm in 1839, when one erected on the roof of a house in New Street, Birmingham, recorded a pressure of 42 lbs. on the square foot. He was greatly inclined at one time to purchase a similar instrument, but was now glad he did not, as evidently from the result of recent investigations on the subject of anemometry his labours would have been useless. He thought it would be difficult for Scilly to be surpassed for a good exposure, with its few hills and trees, and opportunities for observation by the great number of gales experienced. An inhabitant of St. Mary's had informed him that the waves had sometimes beaten 100 feet high against the cliffs.

Mr. R. W. MUNRO remarked that the construction of the Kew pattern Robinson anemometer would not allow of its being elevated to any great height on the roof of a house, weighing as it did some 3 cwt. Mr. Curtis and Mr. Dines had agreed that it was essential that the instrument should be beyond the influence of eddies, etc. Those which he had erected lately had been on a cast-iron hollow column about 10 inches in diameter at a height of about 8 feet 6 inches. To add a few feet to the height would mean a much greater strain on the support.

Mr. R. H. SCOTT said that the President had described the exposure of anemometers in these islands as unsatisfactory, but he could say that the exposures on the Continent were not a whit better. A proposal was at present in his hands for submission to the International Meteorological Conference in Paris in September, to the effect that the Recknagel's anemometer should be used as the universal standard to which all wind observations should be referred. This instrument was not much larger than an ordinary ink-bottle, and he (Mr. Scott) could not see how such an instrument could be erected and read on a pole or scaffolding 40 feet high. As to foreign meteorological stations an eminent British meteorologist had told him that he had never seen a station on the Continent which would pass muster as to instrumental exposure. It had been remarked by some of the speakers that there were many sites available for anemometers on the exposed west coasts, but he (Mr. Scott) would observe that really exposed places were practically uninhabitable. In some places, near Loop Head at the mouth of the Shannon, storm shutters had to be up during the winter on the exposed side of the houses. He (Mr. Scott) had obtained permission from the Council to send an advanced copy of the present paper to Vienna for the *Meteorologische Zeitschrift*, and he hoped that the appearance of this in German would show our foreign friends that we in England were working at wind records, and so would be of use in connection with the discussions in Paris in September.

Mr. R. INWARDS thought that in the case of the Holyhead experiments it would be interesting to study the effect of the long ramp or sloping side of the pier, about a third of a mile in length, and which must tend to produce an upward current of air just as it was calculated to convert a horizontal wave into a fling of upward spray. Now the Dines anemometer, in the case of an actually vertical current, would not register any pressure at all, indeed, the air blowing up and across the mouth of the tube would tend to produce a partial vacuum on the principle of the aspirator, and this would apply in a minor degree to any current deflected upwards or downwards, so that a difference might be expected to occur in the readings of the two anemometers wherever there was a vertically deflected

current of air. He supposed a lamp would be employed to prevent the water in the cistern from freezing at low temperatures.

Mr. B. LATHAM said he thought that the three anemometers at Holyhead were scarcely comparable, being as they were at different heights above the ground, and that in turn being of varying elevation above the water surface. The different currents caused by rocks studding a stream were similar in their way to the effect of buildings, etc., in causing eddies. He hoped the question would be thoroughly discussed, for the one reason he had never had an instrument erected himself was because of the unsatisfactory state of the question.

Mr. C. E. PEEK said that the Water Tower at Rousdon on which the anemometers were placed was 60 feet in height. The Robinson anemometer was 5 feet from the roof, and the Dines pressure-tube instrument about 10 feet above the cups of the former. He did not think sufficient observations had yet been taken to make a proper comparison between the two anemometers.

Mr. R. H. CURTIS, in reply, said that he had no doubt at all as to 2·2 being the correct factor for the Kew pattern anemometer, and in this opinion he was confirmed by the results of some direct comparisons he had recently been able to make between the records of an instrument of this type and those of a pressure-tube anemometer erected side by side at Mr. Peek's observatory at Rousdon. He was not able to give a general answer to Admiral Maclear's question as to the height at which an anemometer ought to be placed above the roof of a building, because this depended entirely upon the character of the building—its shape and size, and must be specially determined for each case in which there was no alternative but to place an anemometer in such a position. At Holyhead it was clear that 30 feet above the roofs of the sheds was insufficient; but on the other hand, at Rousdon, he was satisfied that the cups, placed 5 feet above the apex of the pointed roof of the tower, were in a good position and clear of any disturbance, because in this case the superficial area of the tower was small, and the wind striking it flowed off at the *sides*, which was the path of least resistance, and the high tapering roof could of itself exert no appreciable lifting effect upon the stream of air striking it. He had made some experiments on the subject on the roof of the Meteorological Office, by means of light streamers hoisted at intervals of a few feet up to 20 feet, which was as high as he could go; but up to that height there was evidence of strongly-marked eddies caused by the building. The ramp to which Mr. Inwards had referred could not in the least affect the vane of the pressure-tube instrument, which was carried upon an iron pole at a height of 44 feet above the ground. In that position the vane was remarkably steady; and, indeed, it was a surprise to those who had been accustomed to watch the behaviour of vanes in the neighbourhood of buildings to note how very free from oscillation it became when exposed to a stream of wind which was not affected by artificial obstructions. The difference in level above the sea of the cups of the Robinson and the vane of the pressure-tube was only about 8 feet, and this difference was too slight to affect the result as suggested by Mr. Latham. Referring to the sketch shown by Dr. Mill, he said he had observed a somewhat similar effect in front of a large block of buildings open to the south-west; when a South-west gale blew before the block the wind current was split, and on passing along the front of the building you first experience a strong wind blowing against you, then a calm near the centre of the block, and immediately after passing the centre a strong wind at your back.

ARCTIC HAIL AND THUNDERSTORMS.

By HENRY HARRIES, F.R.Met.Soc., Mem. German Met.Soc.

[Read June 17, 1896.]

At the Meeting of the Society held on June 19, 1895, I read a paper on "The Frequency, Size, and Distribution of Hail at Sea" (*Quarterly Journal*, vol. xxi. pp. 230-240), in which it was demonstrated that, contrary to certain views which had been published, hail is a very common phenomenon out on the open ocean between the latitudes of 35° and 60° N. and S., not uncommon between the parallels of 30° and 35°, and occasionally met with in the Equatorial regions between 30° N. and 30° S. At that time I had not consulted more than two records in very high latitudes, one Arctic, the other Antarctic, and consequently was not in a position to say anything further about the cold zones than that each record contained references to hail. Believing the subject to be one of much more than passing interest, one which, through the want of a collection of reliable facts, has evidently been but imperfectly understood, and is therefore in need of sufficiently trustworthy evidence to enable us to arrive at a just appreciation of the physical laws which are called into play in the production of the phenomena, I have since extended the scope of my investigation to hail and thunderstorms in high northern latitudes, to see how far actual observations lend their support to, or contradict, the theories which from time to time have been advanced. Various opinions have been expressed as to the practical absence of these phenomena in high latitudes. According to the Hon. Rollo Russell "Hail is almost or quite unknown in the Arctic regions," and "Thunderstorms may be said to be equally rare." M. Arago modified his view slightly on learning that a thunderstorm had occurred in Iceland, but he seemed to cling to his earlier idea for still higher regions. M. Élisée Reclus tells us that "lightning has never been seen in the sky" in Iceland and Spitzbergen; and Mr. Thomas Russell states in his recently published *Meteorology*, that "lightning is always an attendant of a hailstorm"; while Mr. Scott, in his *Elementary Meteorology*, states that hail hardly ever falls except during thunderstorms. In most cases the opinions held have been based upon altogether inadequate information, the investigators having to be content with the observations of two or three visitors for a few months, and these have been accepted as sufficient to determine the problems for the entire Polar area. We have not got the logs of hundreds or even of dozens of ships dotted at convenient intervals all round the Pole in every month of the year, but perhaps only one log in one season, two in the next, and none at all in another year. The results, therefore, must not be treated in precisely the same manner as if we were discussing the returns from a complete organisation of reporters on shore, deducing from them definite conclusions as to the frequency of any particular phenomenon. Individually both hail and thunderstorms are restricted to infinitesimally small areas, and, as Capt. Duperrey said to M. Arago, "the chances are against each navigator being at any given point of the ocean on one of the twenty days which constitute the mean annual number of days of thunder observed on land in our latitudes."

Dealing with the general character of the climate of the Arctic regions, it can be shown by extracts from meteorological logs and from published works, that the popular notions on the subject are very erroneous, for the weather in the Frigid Zone is quite as variable and uncertain as it is with us. There are extremes of wet periods and of dry periods, of brilliant and prolonged sunshine as well as of dense impenetrable fog, of genial warmth as well as of excessive cold. Temperature is liable to violent fluctuations, a range of from 20° to 40° in a day not being uncommon, while changes of 17° in 4 hours, of 31½° in 6 hours, and even 18° in a single hour are not unknown. There is abundant ground for saying that the precipitation assumed for the Arctic regions (16 in. to less than 8 in.) by some writers is very largely underrated, for the works of northern voyagers teem with records of torrential rains up to the highest latitudes attained by man. In July 1827, between 82° N. and 83° N., in 23° E., Lieut. (afterwards Sir) James Clark Ross remarked: "It has been a constant source of astonishment to all those who have been on the former voyages with the expeditions to the Polar Seas to find such very frequent and heavy rains in this climate, and to us it has been a most unwelcome as well as unexpected foe."

Seeing that we can have all these climatic variations there is no apparent reason why the only other meteorological phenomena, hail and thunderstorms, should not be experienced there as well as elsewhere, being more frequent perhaps in one locality than in another, just as in Europe and other countries.

So far then as the general atmospheric conditions are known there seems to be no ground for supposing that hail and thunder can only happen by accident, as it were, in high latitudes. The one or two instances of the phenomena, of which writers on the subject have heard, cannot be regarded as in any way violating natural laws. Owing to difficulties which do not affect other parts of the globe we are not in a position to ascertain precisely—not even generally—how often they occur within the extensive region round the Pole; but assuming that they are not so frequent as in the tropical and temperate zones, it can, I think, be shown that they happen much more frequently than the various text-books would lead us to expect.

Having thus far dealt with those features of the Arctic climate which would appear to have some connection with the origination of one or other, or both, of the phenomena under discussion, we come to the facts recorded by northern travellers.

In the first place, I will deal with the observations contained in the Meteorological Office log-books of ships going anywhere beyond the 60th parallel; and I have here to acknowledge the readiness with which the Meteorological Council sanctioned my consulting the logs and making use of those indispensable records for the purposes of this discussion. No attempt was made to go through the whole of them, for the labour would have been too great, but I took the first hundred Arctic logs that came to hand, whether they contained one or more observations a day. The majority of these cover the 40 years down to 1895, several of the older volumes going much farther back, even to the year 1818. Out of the whole number eight had to be laid aside in consequence of the letter "h" being used indifferently for "hail" and for "haze," and no clue being

afforded as to which element was intended. This left 92 logs available, and out of this number no fewer than 73 show that hail was experienced at some time or other, that is, 79 per cent of the observers, in other words, four out of five visitors to the Arctic regions, fell in with hail. The observations are distributed over all parts of the northern seas visited by ships—between Nova Zembla and Greenland, up Davis Straits and adjacent Sounds, and northward of Behring Strait—so that there seems to be no special attraction in one region more than in another. Table I. gives the distribution of hail according to latitude, showing the number of times hail was recorded in each degree of latitude as far north as vessels have gone up to the present.

TABLE I.—The Monthly and Annual Number of Observations of Hail from Latitude 60° Northwards. (Logs only.)

Lat. N.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
82°	1	...	...	...	...	...	2	...	...	...	...	...	3
81	...	...	...	...	...	...	...	...	...	...	...	...	...
80	...	...	...	...	...	1	...	3	...	...	...	1	5
79	1	...	...	...	...	1	...	2	...	...	1	...	5
78	...	...	...	...	1	...	...	...	...	...	...	...	1
77	...	...	...	...	2	...	...	...	...	...	...	...	2
76	...	...	...	1	4	4	...	2	1	...	...	...	12
75	...	...	...	...	1	...	2	...	1	...	...	...	4
74	...	...	...	...	...	...	1	3	...	...	...	...	4
73	...	...	9	1	2	...	...	5	1	...	...	...	18
72	...	...	...	...	...	2	2	1	...	...	...	...	5
71	...	...	2	1	...	1	...	...	...	...	...	...	4
70	...	...	2	...	3	1	...	9	2	3	...	...	20
69	...	...	8	8	2	...	...	3	1	...	...	...	22
68	...	...	2	...	1	...	1	...	...	1	...	...	5
67	...	...	2	...	1	3	...	...	1	2	...	...	9
66	...	...	2	2	...	3	...	1	17	4	...	...	29
65	...	...	1	1	...	1	...	...	5	1	...	...	9
64	...	...	8	4	2	1	1	2	1	2	...	...	21
63	...	...	5	2	...	2	...	2	3	...	1	...	15
62	...	...	3	11	2	...	...	5	4	11	...	...	36
61	...	...	...	3	13	...	...	...	3	1	...	...	20
60	...	12	17	11	3	...	1	...	1	2	...	...	47
Totals	2	12	61	45	37	20	10	38	41	27	2	1	296

From these figures it will be seen that there were in all 296 observations, one-half of which were recorded to the northward of the 66th parallel. The summer visits are clearly indicated here, the vessels leaving for the north towards the close of February or some time in March. In the latter month hail has been observed up to between 73° and 74° N.; in April to 76°; in May to 78°; in June to 80°; and in July to 82°. Then the ships seek lower latitudes, and we have 80° in August, 76° in September, and 70° in October. Vessels wintering far north are very few in number, so that there is an almost complete absence of observations from November to February.

In the "Abstract of the Meteorological Journal kept during the Expedition towards the North Pole," printed on pages 152 and 153 of Parry's *Narrative*, there is no mention of hail having been seen northward of Spitzbergen between June 25 and August 10, 1827, but in Lieut. J. C.

Ross's manuscript notes there are the following entries:—On July 9, when in 82° N., 23¾° E., the weather column gives "Hazy, with small snow and hail," and in the remarks "Soon after we were housed at an early hour in the morning, it began to hail and snow, which, towards the afternoon, turned to small rain." Temperature in the shade 34° at 9 a.m.; 36° at noon; 35°·5 at 3 p.m. On the 23rd, when they had reached the highest latitude then attained to the east of Greenland, 82¾° N., 19¾° E., he has in the weather column at noon "rain and hail at times," temperature, 3 a.m. and 9 p.m. 31°·5. The other observation of hail between 82° and 83° N. is from the log of H.M.S. *Discovery*, at 4 a.m. January 1, 1876, the entry in the column being "ch," cloud "Nim," wind calm, dry bulb − 19°.

Of the five observations north of 80° N., two were registered by Capt. Lofley, of Mr. Leigh Smith's ill-fated steamer *Eira*, on the coast of Franz Joseph Land, on December 15, 1881, "Hail" being written in at Noon, temperature 8 a.m. 29°, 4 p.m. 10°; and on June 4, 1882, at 10 a.m., "Some hail," temperature 30°. When steaming up Smith Sound in August 1876 hail was registered three times on board H.M.S. *Discovery*, twice with the temperature at 33°, and once at 41°.

North of Behring Strait ships have not reached as high a latitude as in the Greenland Seas, but in August and October 1849 H.M.S. *Herald* had hail recorded 15 times between 66° and 71° N., the air temperature 31° to 40°. In September of the previous year she had three records between the Arctic Circle and 68° N., temperature 31° to 39°.

It is unnecessary to go into the details of the whole of the 296 observations of hail. There are many instances with the temperature of the lower atmosphere from 14° to 32°, and Mr. Arnold Pike, on the yacht *Siggen*, wintering in Dane's Gat, Spitzbergen, just under the 80th parallel, notes, on November 10, 1888, with a temperature of 7°, "Snow, hexagonal form, mixed with globular flakes like hail, but soft." Mr. Pike, apparently a visitor to the Polar regions for pleasure, had time to make notes on various subjects, calling attention to little differences, and out of the hundred logs examined his two are the only ones which contain any reference to soft hail, but he also records hail without any qualification, once in Dane's Gat, with the temperature at 25°. The observers, who have plenty of hard work to attend to, content themselves with the bare entry of "h" in the column, or briefly mention in the remarks "Hail," "Hail showers," "Squalls of hail," "Snow, hail, and sleet all day," "A short hail storm," "Smart shower of hailstones, lasted 10 minutes," and so on, clearly indicating that what was falling on these occasions was ordinary hail and not graupel.

As bearing upon the question of the probability of meeting with hail in high latitudes it is significant that not one of the observers expresses any surprise indicating that the phenomenon is considered to be an exceptionally rare one.

Coming now to thunderstorms, it will, perhaps, be expected that, as Mr. Scott states in *Elementary Meteorology*, p. 167, "inasmuch as hailstorms are always associated with thunder and lightning," the 296 records of hail which the logs yield would be accompanied by as many records of thunderstorms, but this is not so. It may be that the atmosphere was in an electrical condition with each fall of hail, but this cannot be determined from the contents of the logs. Instead of about 300 observations of

thunderstorms, *i.e.* thunder, or lightning, or both, the total number appearing in the same volumes is only 59, or one-fifth the number of hail falls. The distribution according to latitude is shown in Table II.

TABLE II.—The Monthly and Annual Number of Observations of Thunderstorms from Latitude 60° Northwards. (Logs only.)

Lat. N.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.	Year.
75°	...	...	1	...	...	...	...	1
74	...	...	...	...	...	...	...	...
73	...	...	...	5	...	...	...	5
72	...	2	1	5	1	1	...	10
71	...	...	...	2	...	...	...	2
70	...	...	...	...	3	2	...	5
69	...	...	...	2	...	...	...	2
68	...	...	...	...	...	1	...	1
67	...	...	...	4	...	...	...	4
66	...	1	2	4	1	2	1	11
65	...	...	...	4	...	...	1	5
64	1	1	1	2	...	1	...	6
63	...	...	...	...	...	...	...	...
62	...	...	...	...	...	...	...	...
61	...	...	...	4	...	...	...	4
60	...	...	1	...	1	1	...	3
Totals	1	4	6	32	6	8	2	59

Here it will be seen that the records of thunderstorms are confined to seven months, there being none in January to April, and November, while May shows only one and December two. August, on the other hand, had more than half the total number recorded.

Of the more southern ones little need be said. In July 1852 Capt. Inglefield, on H.M.S. *Isabel*, had thunder in 60° N., 25½° W., followed by hail three hours later. While at anchor at Ivigtut, 61° N., 48° W., in August 1881 Capt. Alexander Simpson experienced a thunderstorm lasting 13 hours. On the 3rd, "At 6 p.m. a dark, ugly sky began to rise in the north-north-east. At 7 vivid flashes of lightning seen in the north-east. At 8·30 heavy thunder with lightning (sheet and forked), and heavy rain continued throughout the night. Wind light, squally and variable. This is a very unusual phenomenon in these high latitudes." 4th, 4 a.m., l, t, p, r, dry bulb 56°·3, damp bulb, 51°·0 ; 8 a.m., l, t, p, r, dry bulb, 43°·5, damp bulb, 43°·5, "Thunder and lightning continued in the south and south-west until 8 a.m." Although he thought this unusual, the same observer had storms afterwards in still higher regions in 1889, 1891, and 1893. On June 3, 1889, he was in 72° N., 11° W., and at 5 p.m. there were several peals of thunder with heavy rain; next day, about 25 miles to the north-west of this position, he recorded at 8.15 p.m., "Thunder-squall lasting ten minutes, strength 8, with thunder and lightning from south-east going south-west. Very heavy rain." Temperature each day 33°.

In August 1850, H.M.S. *Herald*, off Cape Lisburne, 69° N., 167° W., had at midnight, 4th, c, g, t, l, temperature 47°, and 3 a.m., c, g, q, r, t, l, 46°. "1.15 a.m., vivid fork and chain lightning, commencing as at sunset and darting over all points of the heavens from the horizon, accompanied by thunder. 2.20 a.m., discontinued." In December 1853, H.M.S. *Rattlesnake* had lightning at Port Clarence, 65¼° N., 166¾° W., temperature 5°.

Capt. Milne, s.s. *Eclipse*, had vivid flashes of lightning in 71° N., 71° W., in August 1893, temperature 37°, and on the s.s. *Esquimaux* in the same month of 1888 he had thunder in 71° N., 68° W., temperature 40°. Off Holsteinburg, just under the 67th parallel, on the west coast of Greenland, Capt. James Clark Ross, on H.M.S. *Cove*, on June 1, 1836, had in the weather column at 11 p.m. d, l, t, h, temperature 30°, remarking, "11.30 violent squalls accompanied with hail, thunder, and lightning." This is interesting as being the only instance I have come across in which hail appears simultaneously with either thunder or lightning, Capt. Inglefield's observations, separated by an interval of three hours, being the only other instance within the same day.

In 72° N., 95° W., Sir F. L. M'Clintock, in the s.s. *Fox*, had two flashes of lightning in September 1858, temperature 26°; faint lightning in the following month, temperature 25°; and thunder in August 1859, temperature 35°.

On the barque *Perseverance*, Capt. Murray experienced thunder and lightning with very heavy rain in Repulse Bay, 66½° N., 86¾° W., in September 1892, temperature 31°; and in the same place in August 1883, he had "t, l, 3½, r," temperature 37°·5. In August of the following year, in 64½° N., 87° W., he registered heavy peals of thunder and lightning, temperature 36°; and in May 1895, at Depôt Island, 64° N., 90° W., there was lightning, with snow, temperature 30°.

These observations, from comparatively few visitors, show that thunderstorms are at least possible in all regions from Behring Strait eastward to Davis Strait and the East Greenland Sea, but when we go still farther east, to Barents Sea, I am almost inclined to say that we have discovered the breeding-place of thunderstorms, and this, too, in latitudes where theoretical considerations lead us to infer that electrical displays are to all intents non-existent.

When in command of H.M.S. *Eurydice* in 1854, Capt. Erasmus Ommanney was cruising between 65° and 71° N., 23° and 41° E., and the log shows thunder, lightning, or both, on two days in July, seven days in August, and one day each in September and October, or 11 days in four months, sometimes three entries in one day. The thunder occasionally loud or heavy, and the lightning noted at times as sheet or vivid sheet flashes. Temperature ranging from 37° to 57°.

In Archangel Bay on June 30, 1874, Capt. Bennett of the brig *Luna*, had thunder and rain, temperature 71°·5, and next day, July 1, lightning, temperature 74°·5.

On being released from Franz Joseph Land after losing the *Eira*, Mr. Leigh Smith's party set off in a boat for the coast of Nova Zembla, and on July 25, 1882, distant thunder was heard when in about 75½° N., 48° E. At 7 a.m., August 2, in about 74° N., 54° E., "A fearful thunderstorm came on, with very heavy rain until 9.30 a.m." Sir Allen Young, in the s.s. *Hope*, was about the Nova Zembla coast on the look-out for Mr. Smith and his men, and on July 20, in Little Karmakoula Harbour, Möder Bay, nearly 73° N., thunder, with a heavy shower lasting 15 minutes was experienced, temperature 56°. On August 2, when the *Eira's* boat crew had a storm out at sea, the *Hope* was in the Matotschkin Shar, 73¼° N., and at 8·30 a.m. there was thunder for five minutes with heavy rain, temperature 48°·5. Noon weather b, c, q, t, temperature 58°. Two days later, at 8 p.m., b, t, q, 59°; midnight l, t, r, 55°, and a remark, "Violent storm of thunder and lightning, with heavy rain from 10 p.m. to 1.30 a.m."

Mr. Arnold Pike was in Barents Sea in August 1894, and at noon on the 19th in 72¼° N., 36¼° E., he had c, b, t, "thunder in west; 5 p.m., distant

thunder in east-south-east; midnight, distant thunder in south-east all the afternoon. From 10 to 10.40, a severe thunderstorm with rain passed over head from south-east to north-west."

Thus far the information has been obtained exclusively from some of the original manuscript documents at the Meteorological Office, and it is evident from them that hail observations are fairly numerous up to the highest latitude reached, while electrical disturbances are met with certainly up to nearly 76° N., exhibiting a tendency to be much more frequent in some localities than in others, apparently fairly frequent in the neighbourhood of Repulse Bay, and very frequent in Barents Sea region.

Turning now to the published works relating to various public and private Arctic expeditions, I find that they are very numerous—for there are many scores, if not hundreds of volumes—and a very small proportion of them have been indexed, and that in a most general way. It would occupy much more time than any individual, working single-handed, could possibly afford to wade through them page by page in search of references to what is at best an infrequent occurrence in any part of the world. I have, therefore, contented myself with dealing with a mere handful of the books to obtain what I think is sufficient evidence to induce us to at least modify the views hitherto put forward respecting the topics under discussion.

In nearly every book glanced through, mention is made of falls of hail, and, as in the official logs, none of the authors seem to consider the occurrences as anything very wonderful, no more notice being taken of a shower of hail than if it had been rain or snow, except on very rare occasions, such, for instance, as in the *Journal of a Voyage to the Northern Whale Fishery*, by W. Scoresby, jun., p. 301, where it is stated that on August 23, 1822, in 71¾° N., 20½° W., "The rain of the forepart of the day gave place about noon to hail, which was so sharp that it was scarcely possible to face to windward." In his *Account of the Arctic Regions*, 1820, vol. i. pp. 415 and 424, there are a few notes on thunderstorms and hail up north, in which he states that pellucid spherules of ice "may be said to be unknown" in very high latitudes. Hail is mentioned in the record of the Dutch expedition to the northern part of Nova Zembla, 76° N., in 1597; by the ship *Jonas in the Whale*, in the summer of 1671, between Jan Mayen and Spitzbergen, the hail being figured and described as "round and oblong, all over full of prickles," diameter from 0·15 in. to 0·25 in.; by Phipps in 74° N., on his way to Spitzbergen in 1773; and more modern books contain observations in all latitudes up to 80° N., and in all longitudes, northward of Baring Island, 75° N., 121° W., off the mouth of the Mackenzie River, and about the New Siberia Islands. At Bennett Island, in 77¼° N., 155° E., on August 3, 1881, De Long wrote, in *The Voyage of the Jeanette*, "The weather during the day has been simply disgusting. Fog, rain, or mist as wet as rain, snow-hail, cold and sharp gusts of wind." Next day "A pitiless storm of rain, snow, and hail beat down upon us. . . . I do not remember to have passed a more disagreeable and uncomfortable day . . . the driving snow and hail made it impossible to remain exposed." On September 11, at Semenovski Island, 74¼° N., 134° E., "snow, hail, and sleet falling plentifully."

In the Meteorological Office publication, *Contributions to our knowledge of the Meteorology of the Arctic Regions*, vol. i., will be found many observations of hail. At p. 85, there are no fewer than 42 instances recorded on board H.M.S. *Victory* in the Gulf of Boothia, 70° to 71° N., 92° W., as many as 21 of them being within the month of December 1829, a month whose temperature ranged from a maximum of – 8° to a minimum of – 37°, the mean for the period being – 22°·2.

The books afford a singular confirmation of the logs in showing that the hail of high latitudes falls when, at any rate, no actual thunderstorms are in progress—other than the two instances mentioned from the logs of two naval officers, I have not read of another case of hail and thunder on the same day, and yet there are many hundreds of observations of the former. There may be some special local reason for this. With regard to thunderstorms, I will take those to the northward of America first, and then work eastward.

In Camden Bay, 70° 8′ N., 145° 29′ W., on July 8, 1854, Capt. Collinson, on the *Enterprise*, had the wind very changeable in force and direction from 6 p.m. to midt., and at 7 p.m. there was a thunderstorm, accompanied by rain, temperature rising to 41°. On August 6, 1851, in 70½° N., 146½° W., Capt. Collinson had a violent squall with lightning and rain, accompanied by a rise of temperature of 20°.

At Fort Franklin, on the Great Bear Lake, 65¼° N., Dr. Richardson recorded thunder on May 29, 1826, with rainy weather, temperature 41° to 57·5°.

Commander Pullen at Fort Simpson, 62° N., 121½° W., on June 15, 1850, had heavy thunder and very heavy rain at 2 p.m. At 3 p.m. on May 27, 1851, there was a heavy gathering of clouds from west to south, a few flashes of lightning and distant thunder. The clouds came up fast against a moderate Easterly breeze. At 6 p.m. it fell calm, and there was heavy rain. On the 31st, at 2.15 p.m., he had a heavy squall from West-south-west, with rain, and an occasional peal of thunder. In the middle of this month the weather had been hot, sultry, and oppressive.

On the *Investigator*, in Mercy Bay, 74° N., 118° W., at 8 p.m. on November 3, 1851, a flash was seen resembling sheet lightning in the south-west, and at the same hour on November 13, 1852, there was a most vivid flash of lightning in the south-east. On August 15, 1850, in about 70½° N., 148° W., the weather assumed a highly electric appearance, with the air close and oppressive, leading to thunder, vivid flashes of lightning, and heavy rain. Temperature rose from 34° to 45°.

In Parry's first voyage for the discovery of a North-West Passage, there was a similar remark to that made in Mercy Bay in 1851. When at anchor in Winter Harbour, 74¾° N., 110¾° W., at 9 p.m. of September 24, 1819, "A vivid flash of light was observed, exactly like lightning."

In Capt. Ommanney's weekly manuscript newspaper, *The Aurora Borealis*, appeared the following:—"It has been asserted by various authors that there is no thunder and lightning within the Arctic Circle; this we are able to disprove from the fact of a vivid flash being seen, accompanied with a loud report, on the night of August 28 [1850], when in Wellington Channel," 75° N., 95° W.

The 8th of the following November, the *Lady Franklin*, in Assistance Bay, 74¾° N., 94¼° W., registered two flashes of lightning in the south-east at 3 p.m., and at 8 p.m. of January 28, 1851, a flash of lightning was seen by one of the men.

As already intimated, the neighbourhood of Repulse Bay seems to have some

attraction for thunderstorms, for the same observer experienced them hereabouts in four years. Ellis, in the voyages of the *Dobbs* and *California*, states that on July 18, 1746, there was a good deal of lightning and thunder somewhere about Hudson's Strait, adding "which, however, does not frequently happen here." Capt. Smith, of the *California*, had a thunderstorm and rain lasting several hours on July 17-18, 1746, in about 63° N., 75° W., and later, on the 26th, a degree further west, a thunderstorm with showers. Scoresby refers to "Ellis, James, Hudson, and other voyagers" who had observed heavy storms of thunder and lightning in Hudson's Bay. During Parry's stay in the Bay in 1821, he reports that between 11 p.m. and midt. of August 6, "several vivid flashes of lightning were seen to the westward, and succeeded by hard rain for some hours." In the abstract the weather for the 24 hours ending at noon of the 7th is entered as "Hazy and rain, some thunder and lightning," temperature 42° to 36°. Dr. John Rae was here in 1854, and on June 9 there was rain all night with thunder. When Hall was in the Bay in 1865, he experienced a heavy storm in the night of July 15-16.

"At 2.30 a.m. the first thunder-clap that I have *ever* heard in the northern regions occurred, the same being preceded by sharp lightning. A little while after, loud thunder pealed forth here, there, everywhere around Repulse Bay, especially away in the direction of Gibson's Cove, the extreme north-western part of Repulse Bay, where were such piles of heavy black clouds—Heaven's electric battery—and such a continuous roar of thunder therefrom that I could not help thinking of the Almighty hand which holds the elements." Temperature, noon 50°; 3 p.m. 54°; 7 p.m. 45°; 6 a.m. 41°; minimum in the night 37°.

The storm lasted till 4.20 a.m. One of the Esquimaux, member of a community of wanderers over the region between Repulse Bay and Lancaster Sound, in 74° N., told Hall that he had seen lightning twice at Igloolik, Fury and Hecla Strait, 69½° N. The members of the tribe never knew lightning to kill an Esquimaux, but one of the women said that in the country she came from it struck *red* dogs; so they always killed red puppies. From this it is evident that the natives are familiar with electrical manifestations.

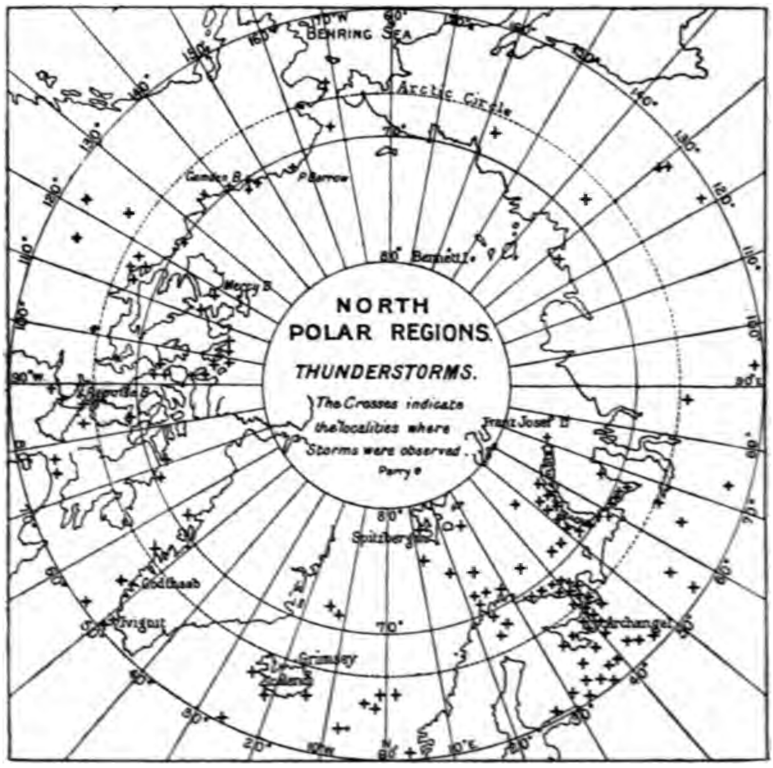
Another storm broke over the locality a week later, on the morning of July 24; the record at 6 a.m. being "fog, passing showers, thunder, and lightning; thermometer lowest last night, 39°." Judging by the Index there seems to have been a third storm about August 7, but there is no mention of thunder or lightning at page 187, only of a storm which began at south-east, with rain falling in torrents.

From these notes it seems clear that if we had a more numerous and widely-distributed staff of observers in this inhospitable region, noting all the phenomena year after year, and all the year round, as in more temperate climates, we should find that thunderstorms were not nearly so rare as has been asserted, the frequency no doubt depending very greatly on the season, the locality, and other circumstances.

With the view of ascertaining the facts relating to Iceland, I have taken the *Meteorologisk Aarbog* of the Danish Meteorological Institute, and tabulated the records of hail and of thunderstorms at the stations in and near Iceland, in the Färoe Isles, and also up the west coast of Greenland, for the twelve years 1880-91. The observations are taken at three fixed hours daily, in nearly all cases, 8 a.m., 2 p.m., and 9 p.m., Berufjord adopting 7 a.m., and Ivigtut 9 a.m., instead of 8 a.m. Unfortunately the records are not perfect, for it seems that if anything occurs other than at the set hours, it may as well not occur at all, for no

record is made of it. For example, the heavy thunderstorm which Capt. Simpson registered at Ivigtut on August 3-4, 1881, was noted by the observer on shore at 8 p.m. on the 3rd, but as it ceased at 8 a.m. next day there is no notice taken of it with the 9 a.m. set of observations, the rainfall being registered as 1·13 in. However, I present in Table III. the results as being the number of days on which each element was noted at one or more of the fixed hours. As they stand they present some curious and interesting features.

At the stations on the Greenland coast the records are by no means



numerous. Upernivik, the most northern station, had more than four times as many days of hail as Jacobshavn, $3\frac{1}{2}°$ to the south, but no thunderstorm occurred at either station at any of the fixed hours. Godthaab had about 4 days per annum of hail, with a November maximum, Ivigtut 2 days a year, and an April maximum, the few thunderstorms at both places being at the end of summer.

Grimsey is a small island lying north of Iceland, and immediately beyond the Arctic Circle. Its hail record is a very remarkable one, averaging 32 days per annum, with a December maximum of 6 to 7 days, and no falls in July to September. Yet with a total of 379 days of hail not a single thunderstorm would appear to have passed over the island.

TABLE III.—Showing the Number of Days on which Hail and Thunderstorms were Registered in the 12 Years 1880 to 1891. Hail on the Upper, Thunderstorms on the Lower Line for each Station.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.
Upernivik. 10 ft.	...	...	...	...	1	1	...	...	5	2	...	...	9
72° 47′ N., 55° 53′ W.	...	...	...	...	...	...	...	...	...	...	...	...	*0*
Jacobshavn. 41 ft.	...	...	...	...	...	...	...	1	1	...	...	...	2
69° 13′ N., 50° 55′ W.	...	...	...	...	...	...	...	...	...	...	...	...	*0*
Godthaab. 37 ft.	2	1	2	8	3	1	...	...	7	8	12	2	46
64° 11′ N., 51° 46′ W.	...	...	...	...	...	...	...	*2*	...	...	...	...	*2*
Ivigtut. 16 ft.	...	3	2	5	3	2	...	...	1	...	4	2	22
61° 12′ N., 48° 11′ W.	...	...	...	...	...	...	*2*	*3*	...	...	...	...	*5*
Grimsey. 8 ft.	64	47	57	36	18	2	...	...	...	27	50	78	379
66° 34′ N., 18° 3′ W.	...	...	...	...	...	...	...	...	...	...	...	...	*0*
Stykkisholm. 37 ft.	3	...	...	1	1	...	1	...	1	5	3	4	19
65° 5′ N., 22° 46′ W.	*4*	...	*1*	...	...	...	*2*	...	*3*	*1*	*1*	*4*	*16*
Berufjord. 30 ft.	2	8	1	...	...	...	1	...	...	...	3	1	16
64° 40′ N., 14° 15′ W.	*4*	*8*	*1*	*1*	...	*1*	...	...	*1*	*1*	*3*	*2*	*22*
Vestmannö. 26 ft.	55	51	33	8	5	3	3	1	2	10	16	45	232
63° 26′ N., 20° 18′ W.	*4*	*7*	*6*	*2*	...	...	*2*	*1*	*2*	*1*	*2*	*3*	*30*
Thorshavn. 30 ft.	48	32	23	6	8	...	...	...	3	4	16	25	165
62° 22′ N., 6° 44′ W.	*7*	...	...	*1*	*2*	*1*	*1*	...	...	...	*3*	*4*	*19*

Stykkisholm and Berufjord do not differ very much on the yearly averages, both being from one to two days per annum of hail and of thunderstorms, the most western station having the maximum hail in October, and thunderstorms in December and January, the eastern station each element most frequent in February. At Vestmannö, which is not very far from Stykkisholm, the figures show 19 days per annum of hail, with a January maximum, and 3 days a year of thunderstorms with a February maximum. Thorshavn, in the Färoe Isles, has about 14 days a year of hail, and less than two days a year with thunderstorms, January showing the maximum for each. Taking the three stations on the Iceland coast, it appears that thunderstorms occur on the island at least from four to five days a year on the average; and as to the statement that Iceland storms are confined to the winter, it will be seen from the table that May is the only month which has escaped, but there is a distinct predominance in winter, for out of the 59 days tabulated, 46 are in the six months, October to March. After all, facts like these, which are limited to occurrences at three specified hours instead of covering the whole period of 24 hours, can only be regarded as affording us a very partial view of the whole truth, and I think we are justified in assuming that electrical storms are more frequent in Iceland and at the other stations than appears from the figures given above.

Passing on to the north-eastern space of the Arctic Seas, I will first of all deal with records from ships plying in these waters.

On April 4, 1815, Scoresby had thunder and lightning in 65° N., near the meridian of Greenwich, with temperature 42° to 37°; and on July 15 there was thunder and much lightning in 63° N., 1° W. The most northern thunder-

storm was recorded by Capt. Johansen between Bell Sound and Icefjord, Spitzbergen, latitude 78° N. Lieut. Otto, in command of the s.s. *Albert*, in November 1872, had lightning in 75¾° N., 10½° E., the temperature at the time being about 32°. The 1878 Dutch Expedition in *De Willem Barendsz* visited Bear Island, 74½° N., 19½° E., off the south of Spitzbergen, and on July 17, with a heavy appearance to the westward, there was lightning at 8 a.m. (temp. 45°·2) and noon (temp. 47°·8). Two days later, in 73¼° N., 25½° E., lightning was again recorded, temp. 45°·7. During Count Wilczek's voyage in the *Isbjorn* in 1872, thunderstorms, with the temperature rising to the very high level of 61°·6, were observed beyond Hope Island in 77° N., 27° E. Payer states that off the Matotschkin Shar on September 14, 1871, "Heavy thunderclouds lay over our heads, just as they do in the region of the Trade-winds, and every moment threatened to discharge themselves."

In *A Polar Reconnaissance*, Capt. Albert H. Markham states at p. 175, "Whilst on the Matyushin Shar [June 1879], we heard some distant claps of thunder. Knowing how very unusual atmospheric phenomena of this description are in high latitudes, we attributed the noise to the fall of a large quantity of snow from the summit of one of the adjacent cliffs, but subsequent reports convinced us that the noise was really due to the elements, and not to an avalanche."

The summer of 1870, however, proves to have been quite an exceptional one in this region from the number of observers who chanced to be there to report storms over a very considerable area, all the observations with one exception being far beyond the Arctic Circle.

In vol. i. of *Meteorologische Beobachtungen angestellt auf Schiffen der Russischen Flotte*, I find that the corvette *Warjag* made a cruise into these waters during this summer, and on June 30, in 71° N., 29° E., she fell in with her first thunderstorm, of two hours' duration, temperature 53°·6 ; on July 2, in 68¼° N., 39¾° E., another with temp. 44·6 ; next day she had lightning in 67½° N., 41¼° E., temp. 45°·5 ; on the 6th, in 64½° N., 40¼° E., a thunderstorm, temp. 63°·9 ; on the 25th, in 71° N., 53½° E., her fifth storm, temp. 50° ; on the 29th, in 71¼° N., 47½° E., her sixth, temp. 46°·8 ; and next day her seventh and last, in 71° N., 45¾° E., temp. 45·5.

The above can be compared and combined with the following:—

Mr. James Lamont, in *Yachting in the Arctic Seas*, at pp. 145, 146, describing the weather on the west coast of Nova Zembla towards the end of June 1870, says, "We had been enjoying nine days of the most lovely weather imaginable, not a cloud to veil the blazing sun, nor a breath of air to ruffle the calm glassy sea; but the morning of June 30 saw a change. A brisk breeze from the South-west brought with it a dense fog. We had hove-to off Pilz Bay [73° N.] during the night, and seized an interval of clearer weather to go ashore. The plains were very wet, the air oppressive, and the deer had retreated to the high mountain-land. . . . During the day we heard loud and prolonged thunder. To the south of us was the heavy rain-cloud from which presently fell drenching showers, but no lightning was seen. Pakhtusof, too, heard thunder on June 10 [? 1835] in Matotschkin Shar, though it is considered a phenomenon of rare occurrence in such high latitudes."

Capt. Torkildsen, of the schooner *Alpha*, on July 2, in 70½° N., 60° E., had heavy thunder and very heavy rain for a couple of hours, temp. 57°. Next day, in the same locality, east of Waigat Island, he had thunder and lightning. Cruising between Jugor Strait and Kara Bay, 70° to 69° N., 60° to 68° E., he had thunderstorms on the 6th, 7th, 9th, and 10th, the mean daily temperature being 43° to 50°. Losing his ship, he took over the command of the schooner *Island*, and on July 29, in 72° N., 68° E., he experienced another thunderstorm.

Capt. Ulve, of the schooner *Samson*, in 74½° N., 55° E., had violent thunderstorms, with extraordinarily large rain-drops, on July 8 and 9, temp. 50°.

Capt. Mack of the schooner *Polarstern*, had thunder and lightning on the same two days in 75° N., 56° E.; and on the 21st, in 71½° N., 56° E., another storm, with temperature up to 60°.

Lastly, Capt. Qvale, on the yacht *Johanna Maria*, experienced thunder squalls from NNE on July 10, in 70° N., 59° E.

Here then we have from June 30 to July 30 no less than six ships giving between them 21 observations of thunderstorms on 12 separate days. Presumably the events recorded on the *Warjag* and at Pilz Bay on June 30, were totally unconnected, being more than 500 miles apart. Probably also the storms on the *Warjag* and the *Alpha* on July 2, 3, 6, and 29 were distinct, with from 400 to 500 miles between them. On referring to a map, it will be seen that these storms occurred on both sides of Nova Zembla, in the Barents and Kara Seas. Going back to the *Eurydice* records of 1854, noted in the Meteorological Office log, it is seen that they cover a period of four months in this region with 11 days of storms.

During the forenoon of July 25, 1878, off the north-east extremity of Nova Zembla, in 76° 50′ N., 69° 40′ E., Capt. Johansen, of the schooner *Nordland*, had a heavy thunderstorm with violent rain, temperature 39°·2.

It seems tolerably certain then from these groups of numerous instances, that we have out Nova Zembla way a part of the world where there is an abundant store of electrical energy which sometimes breaks forth with considerable and prolonged violence. In the face of so many observations within a few weeks and in such high latitudes, we are surely justified in taking a different view from that hitherto held regarding Arctic thunderstorms. If the information before us is not sufficient, let us turn to the very excellent series of meteorological observations which are made throughout the Russian Empire under the direction of the authorities at St. Petersburg.

I had commenced to collect the records at the stations north of 60° and up to the Arctic shores, which would have been a very heavy piece of work, the stations being so numerous. Fortunately, before I had proceeded far, I consulted Wild's *Repertorium für Meteorologie*, and in vols. x., xi., xiii., and xvii. found elaborate monographs on "Die Gewitter Russlands" for the five years to the end of 1888, by A. Schoenrock for 1884 and 1885; Emil Berg for 1886; Arthur Beyer for 1887; and Eugen Heintz for 1888. The several authors have followed one plan in discussing the subject of thunderstorms, just as the observers have kept to one uniform system of recording the particulars relating to each storm—whether in Poland or on the Behring Sea, on the Caspian or on the White Sea.

For the purposes of the discussions, the empire has been divided into a number of districts, and the Northern Zone is the one which concerns us. It embraces the governments of Archangel, Olonez, Wologda, and Novgorod, covering an area of nearly 250,000 square miles, almost the whole of it being on the polar side of latitude 60° N., the stations including, in addition to land ones, the lighthouses off the northern shores,

which, of course, are only tenanted during the brief summer season when navigation is possible.

The results of the five separate investigations, so far as they relate to the region to the north-eastward of St. Petersburg, are exhibited in Table IV., giving a variety of particulars connected with thunderstorms, and also some facts bearing upon the question of hail as an electrical meteor. The storms may be said to be wholly confined to the summer months, seldom occurring before April, and as rarely after September or the opening days of October.

TABLE IV.—Five Years of Thunderstorms in Northern Russia.

Year.	Stations.	Thunderstorms.													Hail.	Thunderstorms per Hailfall.	Hail to Thunderstorms.
		No. of Storms.	No. of Days.	Absolute No. of Days.	Storms per Station.	Days per Station.	Per Day.	Duration.			Intensity.			Resultant Direction.			
								Under 1 hour.	1–2 hours.	Over 2 hours.	Light.	Moderate.	Very Heavy.				
								%	%	%	%	%	%	°			%
1884	37	314	282	67	?	8·1	1·11	33	45	22	32	48	20	S32W	18	17	5·7
1885	38	421	377	77	?	11·8	1·22	39	39	22	24	54	22	S43W	40	11	9·5
1886	46	584	514	97	13·2	11·6	1·14	51	34	15	24	61	15	S39W	26	22	4·5
1887	47	714	625	116	16·2	14·3	1·14	50	31	19	27	50	23	S52W	47	15	6·6
1888	56	540	459	102	10·1	8·6	1·18	64	27	9	36	48	16	S29W	28	19	5·2

The only column in the table which does not explain itself is that which gives the thunderstorms per day (Gewitter pro Tag), the figures being arrived at by dividing the number of storms experienced by the number of days on which they occurred—they are liable to have more than one in a day.

There are some very interesting facts disclosed in these figures. I have already pointed out that our knowledge of Arctic meteorology is extremely limited, because we have only information from what is nothing more than an occasional visitor. In Northern Russia, when there were only 37 observers, the absolute number of days on which thunderstorms were registered was 67, itself an abnormally high figure, but as the number of observers increased the thunderstorm frequency rose to over 100 days per summer season in 1887 and 1888, indicating that in some months storms are practically everyday occurrences in one part or another of this area. Naturally the number of storm days per annum per station varies from year to year, but the average in 1887 exceeded 14. In 1885 Petrosawodsk, 62° N., 34½° E., had as many as 22 days with thunderstorms, Wytegra, 61° N., 36½° E., 18. Obdorsk, on the Arctic Circle at the mouth of the Obi, ranges up to 12 days in a year. In still higher latitudes Kola, Teriberka, Swjatonosskij

lighthouse, Orlowskij and other places, are annually made acquainted with thunderstorms; and going much farther east, into Northern Siberia, Turuchansk, 66° N., 87½° E., and Ssredne Kolymsk, 67½° N., 157½° E., have several storms per annum, while even the coldest place on the globe, Werkojansk, 67½° N., 134° E., has an occasional electrical display.

That the thunderstorms of Northern Russia are not very trivial ones is evident from the fact that the duration of more than half of them exceeds an hour, about one out of every six lasting more than a couple of hours. Rather more than a quarter of them are returned as light, and one-fifth of them are very heavy. The direction in which they travel seems to be fairly uniform from year to year, originating in some northern localities and travelling on a south-westerly or south-south-westerly course.

At sea we have seen that the hail records greatly outnumber those of thunderstorms, but here the conditions are completely reversed, for the last column in the table shows that at these land stations the falls of hail form only from 4½ to 9½ per cent of the number of thunderstorms.

What may be the precise explanation—and there must be an explanation—of the peculiarities brought to light in this discussion, both as regards the frequency and the distribution of hail and of thunderstorms in very high latitudes, has yet to be determined. We know absolutely nothing of the condition of the upper atmosphere of the Arctic regions as regards temperature, and so on. We must all hope that Herr Andrée's proposed balloon trip to the Pole will be entirely successful, but even if only partially so, and the aeronauts are compelled to come down much sooner than they expect, we are likely to learn something new about the upper atmosphere of the north. It may be urged that pure hail cannot form in excessively low temperatures, but when the thermometer is anywhere below zero, on board ship or on land, we do not know what the temperature may be at the same time 1000 or 5000 feet overhead. The hail records quoted in this paper have frequently occurred with the temperature of the lower air well above the freezing-point, so that there is nothing unreasonable in accepting the observations as those of hail and not of graupel. Indeed in some of the latest publications, in which symbols are used instead of words, it is clear that hail falls as well as graupel; the Dutch series of circumpolar observations for 1882-83 show both, the hailstones being more than a tenth of an inch in diameter.

If we propose to explain the succession of days of thunderstorms about Nova Zembla by the mingling of the warm waters of the Gulf Stream with the cold waters of the White Sea, we are immediately met with the question: What is there to excite the electrical conditions about Repulse Bay, where there is not a drop of Gulf Stream water, but only a constant flow of icy cold water from the northward?

To enlighten us on these points we require to have a very much more complete and regular system of observations—a larger number of regular observers stationed in all sorts of situations, and this we are not likely to have—at any rate not in our own generation. There is nothing for it, therefore, but to do the best we can with the scanty, often scrappy,

material which is available, and I trust that the facts now brought to the notice of the Society will be of some value to investigators of electrical phenomena, and justify the time spent in collecting the information and in the preparation of this communication.[1]

DISCUSSION.

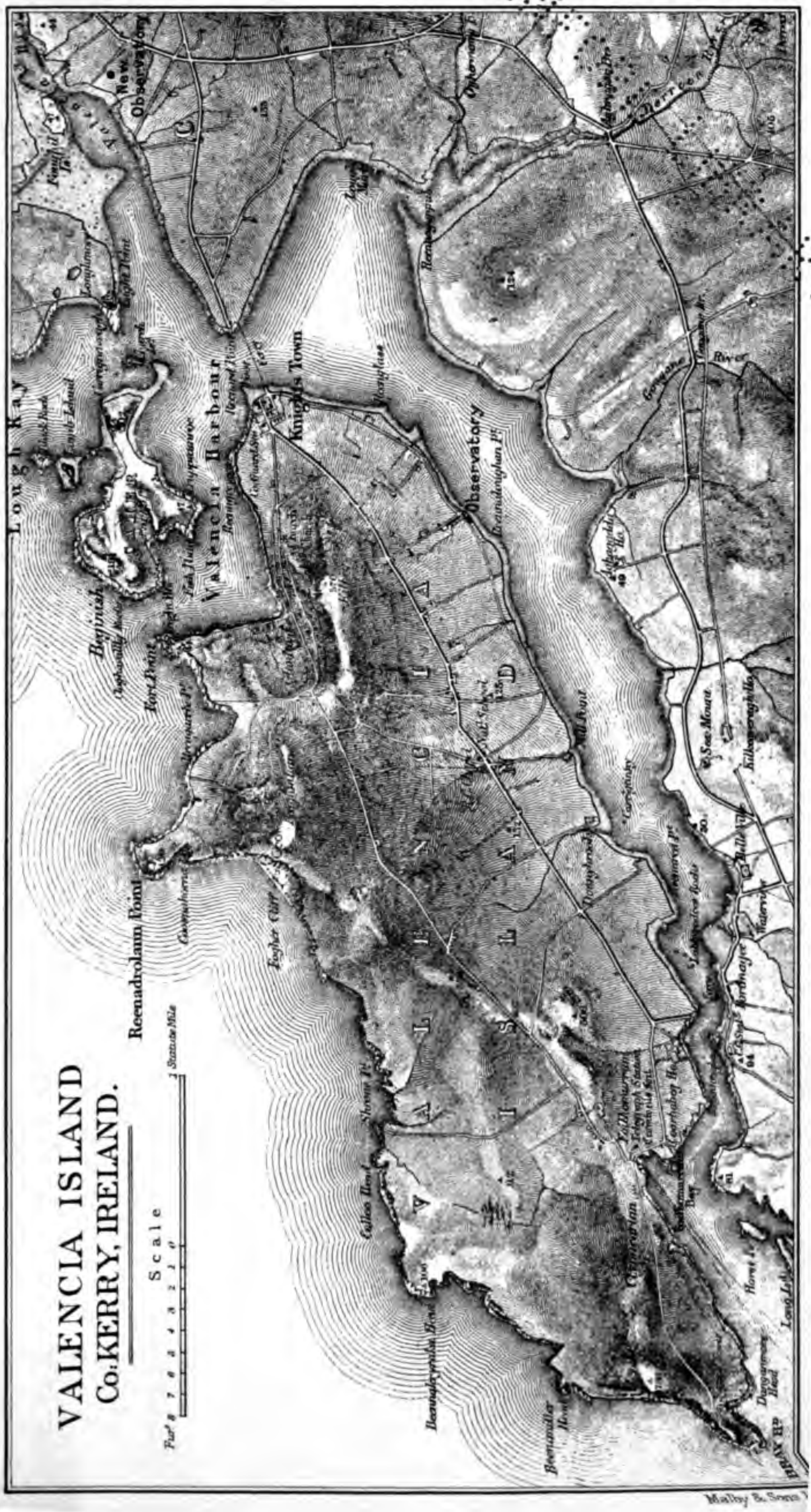
The President (Mr. E. MAWLEY) said that the Society was greatly indebted to Mr. Harries for throwing new light upon the question of Arctic hail and thunderstorms, and also for the time and trouble he had devoted to the extraction from numerous logs all the entries bearing upon it. There appeared to be a discrepancy in either one or other of the Tables, Table II. showing a larger number of thunderstorms for the summer months, while in Table III. there were fewer than at any other season.

Mr. R. H. SCOTT said that he was inclined to think that most of the records of hail brought forward by Mr. Harries were not of hailstones, but of soft hail or "graupel." He was not sure that Mr. Harries was justified in claiming that he had discovered the breeding-place of Arctic thunderstorms.

Mr. R. INWARDS thought that the paper so carefully prepared by Mr. Harries would be extremely useful to future meteorologists, as dispelling another fallacy which was becoming almost a superstition, viz. that thunder and hail occurred but seldom in the Arctic and Antarctic regions.

Mr. W. B. TRIPP said that he had noticed in the paper that the members of a tribe of Esquimaux between Lancaster Sound and Repulse Bay were reputed to have said that Arctic lightning had never been known to kill a human being, while dogs were frequently struck. He should like to know whether the lightning might have less tension in the Arctic regions, or any other peculiarity; also whether there was any definite relation between the deaths from lightning and

[1] Since the reading of the foregoing paper observations of thunderstorms have been noted at the Circumpolar Stations of 1882-3:—Fort Rae, Sodankylä, Bossekop, and Saagastyr (mouth of the Lena). In "further papers relative to the recent Arctic expeditions in search of Sir John Franklin" (*Parliamentary Papers*, 1855), pp. 217-251, Commander Sherard Osborn's Journal shows "t" in the weather combinations on eight days in May, June, and July 1853, between 75¾° to 76½° N., 98° to 106° W., temperatures from 17° to 57°, hail being mentioned twice in June. At page 941 of the same volume Mr. Simpson, Surgeon, states that "Thunder is a rare occurrence at Point Barrow [71° N., 156° W.], but not altogether unknown to its inhabitants, and they say the sound of it is caused by a man spirit, who dwells with his family in a tent far away to the north. This Esquimaux representative of Jupiter Tonans is an ill-natured fellow, who sleeps most of his time; and when he wakes up he calls to his children to go out and make thunder and lightning by shaking inflated seal-skins and waving torches, which they do with great glee until he goes to sleep again." One of their *turngain*, or evil spirits, "strikes a man dead in the open air, without leaving any mark on his body"—possibly this refers to lightning. Franklin's *Narrative of a Journey to the Shores of the Polar Sea* shows five days of thunder in July 1821, between 67° to 68° N., 110° to 117° W., and in addition to the thunderstorms quoted from his *Narrative of a Second Journey*, as having occurred on September 11, 1826, at Fort Franklin, there was another instance on May 29, 1825. Sutherland's *Journal of a Voyage in Baffin's Bay and Barrow Straits* gives lightning on May 23, 1850, in 71½° N., 54¾° W. Lieutenant Fabvre, in the voyage of "La Recherche," gives thunder in the north of Norway on May 15 and 20, 1839; lightning in 70½° N., 22½° E., on July 11 of the same year; thunder and lightning at Archangel on August 12, 1840; and thirteen days later frequent lightning in 71¼° N., 24° E. In Back's *Narrative of the Arctic Land Expedition to the Mouth of the Great Fish River*, 1833-35, there is, facing p. 408, a full page engraving, "Thunderstorm near Point Ogle" (68¼° N., 95° W.) on August 8, 1834. The only remark I have found bearing upon the size of Arctic hail is in Leslie's translation of Nordenskjold's *Voyage of the Vega* round Asia and Europe, vol. i. p. 276. Lieutenant Rossmiuslov in Matotschkin Strait relates that "on April $\frac{28}{17}$, 1769, there was a storm from the South-west, with mist, rain, and hail as large as half a bullet."


VALENCIA ISLAND
Co. KERRY, IRELAND.
Scale
Statute Mile
Reenadrolaum Point
Valencia Harbour
Knights Town
Observatory
New Observatory
Lough Kay
Beginish
Fort Point

the number of thunderstorms in this country, as if there were few deaths one might argue few thunderstorms in the higher latitudes.

Mr. W. Marriott did not see any foundation for the general belief that thunderstorms did not occur in the Arctic regions. On January 23, 1895, a thunderstorm and squall of great severity, accompanied by snow, passed over London, at a time when the temperature was low. In answer to Mr. Tripp, he said that a complete record of the deaths by lightning was given in the Registrar-General's Reports. Inspector-General Lawson had also read a paper before the Society (*Quarterly Journal*, vol. xv. p. 140) which showed the deaths from lightning to be remarkably few—in fact the average for the twenty-nine years, 1852-1880, was only 19, which was less than 9 per 10,000,000.

Mr. B. Latham said that great praise was due to Mr. Harries for bringing this subject before the Society. It was really difficult to conceive a reason why the Arctic regions should be free from thunderstorms when the aurora borealis, which was so common in these high latitudes, was essentially an electrical phenomenon. With regard to the height at which hailstones form, he had at his former residence at the top of Park Hill, Croydon, during a thunderstorm in June 1878, ocular demonstration that the formation could only have occurred a few feet above the surface of the ground. The stones in this storm were about three-quarters of an inch in diameter, and descended so gently that they could not have fallen from any great altitude, while at the bottom of the same hill almost every pane of glass which was exposed to the storm was broken, showing what the effect of increased velocity had been in falling from a greater altitude.

Mr. C. Harding inquired if there was not a strong wind blowing at the time, which would perhaps explain the way in which the hail fell.

Mr. B. Latham said that the air was nearly calm at the time, and that the peculiar sound of the stones clashing together was heard before they were precipitated.

Mr. H. Harries, in reply, said that no satisfactory comparison could be instituted as to the very obvious seasonal differences in the frequency of thunderstorms exhibited in Tables II. and III., to which the President had drawn attention. Table II. is based exclusively on observations obtained from ships, and, as stated in the paper, the Polar seas are practically free from visitors in the winter months. The explanation of the decided preponderance of winter thunderstorms in Iceland is no doubt the same as that for the corresponding feature noticed along our western and north-western coasts—Professor Mohn's "cyclonic," as opposed to "heat," thunderstorms. (The monthly distribution at Bernfjord and Vestmannö on the south coast of Iceland is much about the same as is shown in the Thunder-table for Valencia Island, given in Mr. Cullum's paper which follows.)

CLIMATOLOGY OF VALENCIA ISLAND, COUNTY KERRY.

By J. E. CULLUM, F.R.Met.Soc.

Plate III.

[Read June 17, 1896.]

Introduction.

The observatory at Valencia owes its origin to a recommendation contained in a letter from the President and Council of the Royal Society, bearing date June 15, 1865. This was to the effect that six observa-

tories, meridionally situated, should be established in the British Islands, furnished with self-recording apparatus. These were to be placed "in localities where some permanent establishment of a scientific character exists, and where a certain amount of supervision may be secured." The six stations there proposed were Aberdeen, Armagh, Falmouth, Glasgow, Kew, and Stonyhurst. The letter goes on to say, "To these six stations the President and Council would have been very glad to have added two others, one in the south-west, and the other in the north-west of Ireland. For the former of these possibly Valencia may present a fitting locality, when an establishment shall have been formed there as the connecting link by means of the Atlantic telegraph between Europe and America."

The idea of connecting the management of the observatory with the

FIG. 1.—Valencia Observatory, looking South-east.

telegraph office was not carried further, and it was decided by the Meteorological Committee to create the observatory and control it from London. As funds were not available for the erection of a special building for the observatory, a dwelling-house, known as the Revenue House, was rented and fitted up for the reception of the instruments. This house is situated on the shore of the strait separating Valencia Island from the mainland of Ireland; it was distant three miles from the open sea, so that it was not exposed to any heavy waves.

The station from its geographical position is perhaps the most interesting and important of the whole seven. It is situated on the extreme south-west coast of Ireland, in lat. 51°·54′ N., and long. 10°·18′ W., and is, with the exception of the extremity of the Dingle Peninsula and the Blasket Islands outside that, the most westerly point in Europe. It is open to the full climatic influence of the Atlantic Ocean. The only other station of the

seven observatories approximating to similarity of situation is Falmouth, but there the surroundings are very different from those at Valencia.

The necessity of using an existing house has rendered the exposure of the instruments at Valencia less satisfactory than might be wished. The thermograph was necessarily placed on the first floor, with its bulbs 12 feet above the ground. The anemograph was on the roof, and there are no trees or adjacent buildings to interfere with the wind, but the vicinity is hilly, and the observatory "is in a valley, with hills of about 1000 feet to the south and south-east of it, at a distance of three miles, and with another hill 700 feet high, distant three-quarters of a mile on the north-west of it"; the country towards the other points of the compass is quite open, and the situation for wind is as favourable as in any other inhabited spot on that rugged and exposed coast.

FIG. 2.—Valencia Observatory, looking North-east.

The rain-gauges were placed in the garden in a very good position, and the sunshine recorder was erected on a wall at the southern angle of the house, open to the sun throughout the year.[1]

[1] It should be mentioned that meteorological observations were commenced at Valencia more than seven years prior to the opening of the observatory. At the commencement of the system of weather telegraphy by Admiral FitzRoy, reporting stations were organised over the country. One of these was Valencia, at which place one of our Fellows, Mr. R. J. Lecky, was at that time resident, in charge of the slate works. Mr. Lecky was then, *inter alia*, managing the telegraphic station; and on receipt of the instruments from the Admiral he taught a boy, T. Sullivan, to read them and draw up the telegraphic reports. The first report received from the station which was published was that for 8 a.m., October 8, 1860. From that date the telegraphic reports from Valencia Island were continuous until the observatory was moved to the mainland near Cahirciveen in 1892.

Description of the Instruments.

A full account of the construction of the various automatic instruments has appeared in the *Reports of the Meteorological Committee* for 1867 and 1870, and it will therefore be unnecessary to do more in this place than to describe them briefly.

The barograph and thermograph are both photographic, on the principle originally devised by Sir Francis Ronalds. The barometer tube is of the ordinary pattern, and the record is obtained on the prepared paper, stretched on a drum, by the admission of the light of a lamp through the Torricellian vacuum at the top of the column. The record is in the form of a dark band, of varying width, of which the lower edge reproduces the motion of the actual mercury surface. The drum is driven by a clock, and revolves once in 48 hours, marking its own time scale by interruption of the illumination every two hours. The barograph is further provided with a self-acting temperature correction, which will be found fully described in the accounts of the observatory outfit to which allusion has already been made.

The scale for measurement of the photograms is obtained by means of readings of a standard barometer, which are taken at frequent intervals during the day.

The thermograph is constructed on a principle somewhat similar to the barograph, but modified owing to the necessities of the case. The object photographed is a bubble of air, introduced into the mercury column of the thermometer, which moves up and down with the rise and fall of temperature. The thermometers are long instruments, of which the tubes are twice bent at a right angle, so that the portion of the tube in which the bubble is placed can be brought inside the room in which the lamps and the recording apparatus are placed. By an adjustment of the tubes and lenses the records of the dry and wet thermometers are thrown on the same paper at a convenient distance asunder. The arrangement for marking the time scale is the same as in the barograph. The standard thermometers for the control of the photographic curves are furnished with large bulbs, so as to resemble the thermograph instruments, whose indications they are destined to check.

The anemograph is of the well-known Robinson pattern, with the addition of the Beckley windmill-fan arrangement for recording direction.

The rain-gauge was designed by Beckley, and its chief feature is an ingenious arrangement of the toy known as the Cup of Tantalus. The receiver is circular, and of the area of 100 square inches. The rain is conducted into a cup, which descends as it fills, until an amount of water, corresponding to 0·2 in. of rain, has accumulated. A siphon then comes into action, the cup is emptied, and rises to receive a fresh load. The motion of the cup is recorded on a drum.

In the case of the anemograph and rain-gauge the drums revolve in 24 hours, not in 48.

The only other automatic instrument at the observatory is the sunshine recorder, which is of the pattern known as the Campbell-Stokes, and consists of a glass ball fixed in a frame bearing the cardboard slips on which the solar image falls. These cards are of three kinds—

winter, summer, and equinoctial, to be used according to the varying declination of the sun.

Barometrical Pressure.

In treating of the mean results, the figures for the 20 years 1871-90, making four complete lustra, will alone be dealt with, so that the

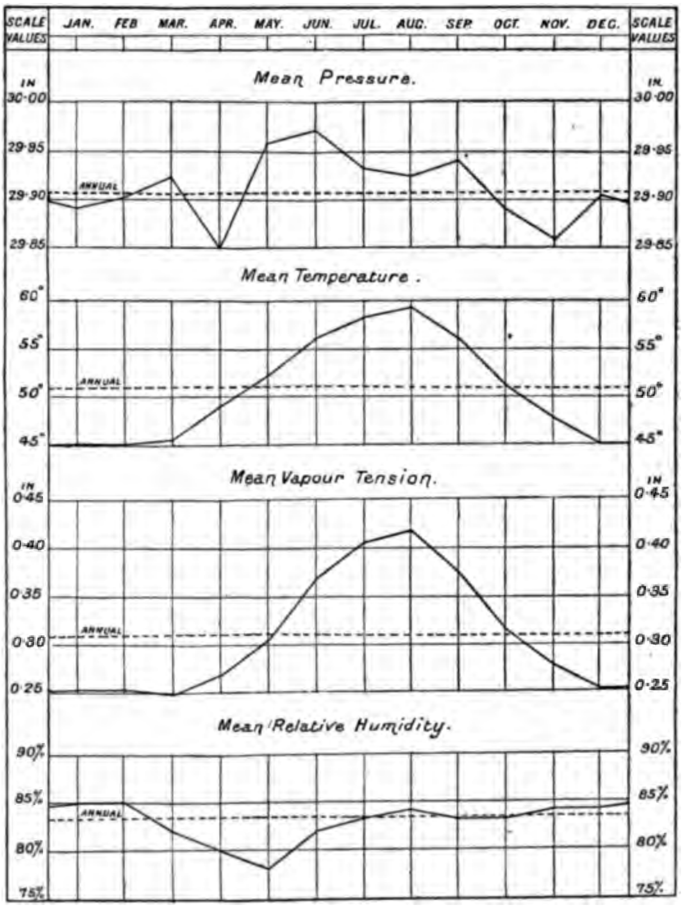


Fig. 3.

numerical results may be comparable with those for other stations for the same interval.

The means for the entire period of 23 years (1869-91) will, however, be found at the foot of the tables, and when dealing with the extreme readings the whole period of 23 years has been taken into consideration.

The curve of mean monthly pressure for the 20 years is given in Fig. 3. It presents features of some interest. There are two maxima, in June and September, and two minima. The first minimum, that in

April, is most striking, owing to the extreme abruptness with which it occurs.

The range has a total amplitude of 0·123 in., from 29·850 in. in April to 29·973 in. in June. The minimum in November is nearly as low as that in April, but the oscillation of pressure is not nearly so marked.

The Diurnal Range of Pressure.

The monthly values of the co-efficients of the first three terms of the harmonic analysis of the records for the 12 years 1871-82, a complete sunspot period, for Valencia as well as for the other observatories, will be found in *Harmonic Analysis of Hourly Observations of Air Temperature and Pressure at British Observatories*, published by the Meteorological Office in 1891. These values were determined by the use of the harmonic analyser devised by Lord Kelvin, and for further particulars reference must be made to the introduction to the publication just mentioned.

TABLE I.—Mean Monthly and Annual Pressure during the Twenty-three Years 1869 to 1891, with the Means for each Lustrum, and for the whole Period (reduced to Mean Sea-level).

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1869	29·748	29·901	29·991	29·952	29·777	30·161	30·042	30·208	29·688	30·117	30·024	29·822	29·953
1870	29·871	29·768	30·090	30·142	29·977	30·197	30·027	30·043	30·004	29·710	29·770	29·905	29·959
1871	29·761	29·898	29·940	29·73[illegible]	30·109	29·963	29·805	29·986	29·888	29·811	29·971	30·046	29·909
1872	29·426	29·545	29·687	29·950	29·998	29·865	29·874	29·965	29·853	29·696	29·599	29·441	29·742
1873	29·516	30·144	29·803	30·112	29·995	29·990	29·857	29·896	29·968	29·847	29·892	30·184	29·934
1874	30·001	29·825	30·184	29·808	29·993	30·130	29·951	29·941	29·815	29·814	29·964	29·890	29·943
1875	29·664	30·020	30·121	30·003	29·956	29·867	30·042	30·012	29·943	29·678	29·822	30·036	29·930
1876	30·148	29·718	29·620	29·814	30·200	29·985	30·097	29·944	29·794	29·772	29·733	29·281	29·842
1877	29·658	30·015	29·818	29·634	29·835	29·936	29·936	29·811	30·075	29·920	29·565	30·034	29·853
1878	30·194	30·158	30·205	29·733	29·677	29·874	30·098	29·716	29·986	29·684	29·966	29·775	29·922
1879	29·873	29·485	29·932	29·684	30·095	29·676	29·853	29·777	29·932	30·152	30·309	30·201	29·914
1880	30·237	29·641	29·969	29·870	30·128	29·960	29·905	30·015	29·953	29·965	29·874	29·931	29·954
1881	29·862	29·786	29·848	29·923	30·073	29·929	30·003	29·848	29·957	29·925	29·660	29·892	29·892
1882	30·219	30·109	29·999	29·705	29·963	29·903	29·776	29·969	29·900	29·773	29·765	29·649	29·894
1883	29·688	29·863	30·016	29·941	29·964	29·979	29·848	30·007	29·811	29·959	29·779	30·251	29·926
1884	30·008	29·676	29·766	29·792	29·938	30·120	29·860	29·979	29·958	30·139	30·166	29·862	29·939
1885	29·745	29·521	30·110	29·737	29·803	30·084	30·167	29·967	29·837	29·846	29·771	30·194	29·899
1886	29·754	30·055	29·795	29·886	29·881	30·047	29·842	29·924	29·879	29·676	29·875	29·704	29·860
1887	29·887	30·211	30·099	30·059	30·121	30·185	30·025	29·978	29·979	30·175	29·696	29·895	30·026
1888	30·173	30·168	29·667	29·952	29·993	29·908	29·777	29·959	30·165	30·026	29·674	29·808	29·939
1889	30·159	30·093	30·028	29·781	29·764	30·065	29·974	29·901	30·067	29·709	30·184	30·084	29·984
1890	29·740	30·134	29·844	29·877	29·753	29·994	29·972	29·934	30·051	30·184	29·898	29·964	29·945
1891	30·104	30·361	29·931	29·925	29·834	29·956	29·998	29·803	29·920	29·578	29·774	29·833	29·918
Means 1869–91	29·889	29·917	29·933	29·870	29·949	29·990	29·945	29·938	29·931	29·876	29·858	29·899	29·916
Means 1871–75	29·674	29·886	29·947	29·921	30·010	29·963	29·906	29·960	29·893	29·769	29·850	29·919	29·892
1876–80	30·022	29·803	29·909	29·747	29·987	29·886	29·978	29·853	29·948	29·899	29·889	29·844	29·897
1881–85	29·904	29·791	29·948	29·820	29·948	30·003	29·931	29·954	29·893	29·928	29·828	29·970	29·910
1886–90	29·943	30·132	29·887	29·911	29·902	30·040	29·918	29·939	30·028	29·954	29·865	29·891	29·951

Of late years the numerical calculation of the hourly means of pressure has been completed for all the observatories up to the year 1890; in the case of Valencia and three other stations this work has not

yet been published, but I have received permission from the Meteorological Council to extract from it the results for the four lustra (1871-75, 1876-80, 1881-85, 1886-90), and have calculated the means of these for the 20 years in table II.

TABLE II.—MEAN HOURLY VALUES FOR PRESSURE IN EACH MONTH DURING THE TWENTY YEARS 1871 TO 1890.

Hour.	Jan.	Feb.	Mar.	April.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
0	29·868	29·883	29·907	29·829	29·942	29·956	29·918	29·911	29·926	29·867	29·841	29·889	29·895
1	29·862	29·879	29·902	29·825	29·936	29·950	29·912	29·906	29·921	26·863	29·836	29·883	29·890
2	29·859	29·876	29·899	29·819	29·930	29·944	29·906	29·900	29·916	29·859	29·833	29·880	29·885
3	29·858	29·869	29·891	29·814	29·924	29·937	29·899	29·894	29·909	29·853	29·829	28·880	29·880
4	29·853	29·864	29·885	29·811	29·920	29·933	29·895	29·888	29·905	29·850	29·825	29·875	29·875
5	29·849	29·863	29·884	29·809	29·919	29·934	29·893	29·887	29·903	29·850	29·824	29·870	29·874
6	29·848	29·865	29·886	29·814	29·925	29·938	29·898	29·891	29·906	29·853	29·825	29·870	29·877
7	29·850	29·868	29·889	29·818	29·928	29·941	29·902	29·895	29·912	29·856	29·827	29·872	29·880
8	29·856	29·877	29·895	29·824	29·933	29·946	29·907	29·900	29·918	29·866	29·835	29·877	29·886
9	29·863	29·882	29·898	29·826	29·936	29·949	29·909	29·903	29·922	29·872	29·841	29·885	29·891
10	29·872	29·890	29·904	29·831	29·940	29·952	29·912	29·907	29·927	29·876	29·848	29·894	29·896
11	29·876	29·892	29·904	29·831	29·941	29·953	29·914	29·908	29·927	29·877	29·850	29·897	29·898
Noon	29·873	29·893	29·904	29·831	29·943	29·955	29·916	29·909	29·926	29·877	29·844	29·891	29·897
13	29·863	29·885	29·900	29·828	29·942	29·954	29·915	29·909	29·924	29·870	29·836	29·881	29·892
14	29·856	29·878	29·893	29·827	29·942	29·954	29·916	29·909	29·921	29·867	29·829	29·875	29·889
15	29·853	29·872	29·888	29·821	29·939	29·951	29·914	29·906	29·916	29·862	29·824	29·872	29·885
16	29·856	29·871	29·887	29·818	29·938	29·950	29·912	29·904	29·913	29·861	29·826	29·878	29·885
17	29·858	29·871	29·887	29·817	29·936	29·947	29·910	29·902	29·912	29·862	29·828	29·881	29·884
18	29·862	29·878	29·892	29·819	29·937	29·948	29·911	29·903	29·915	29·868	29·835	29·886	29·888
19	29·864	29·883	29·898	29·821	29·939	29·949	29·913	29·905	29·918	29·871	29·839	29·887	29·891
20	29·867	29·886	29·904	29·827	29·943	29·951	29·917	29·911	29·925	29·873	29·842	29·890	29·895
21	29·868	29·885	29·907	29·832	29·950	29·955	29·921	29·915	29·926	29·873	29·843	29·890	29·897
22	29·868	29·886	29·909	29·832	29·953	29·960	29·925	29·915	29·927	29·873	29·845	29·892	29·898
23	29·867	29·884	29·909	29·830	29·950	29·957	29·923	29·912	29·924	29·870	29·842	29·890	29·897
Midnt.	29·866	29·884	29·908	29·829	29·948	29·953	29·920	29·909	29·922	29·866	29·843	29·889	29·895
Means	29·862	29·879	29·897	29·823	29·937	29·949	29·911	29·904	29·918	29·866	29·835	29·883	29·889

Tables III. and IV., giving the extremes of pressure in the several months for the entire period of 23 years, are the more valuable, as compared with similar tables for ordinary stations, as they are compiled from continuous records. It must be admitted that in some few cases the absolute extreme, maximum or minimum, may have been lost, owing to insufficient illumination, for the arrangement of the barograph is such that only a space of about 3 inches receives light, so that in case of a very sudden oscillation of pressure the barograph tube must be raised or lowered so as to secure that the top of the mercurial column shall not pass out of the illuminated space.

The absolute extremes show a considerable range, from 30·940 in. on January 14, 1891 to 28·070 in. on January 15, 1871, giving a difference of 2·870 in.

The following values show the total range of the barometer for each month during the 23 years:—

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
2·870	2·411	2·420	1·919	1·910	1·526	1·425	1·622	2·081	2·329	2·462	2·399

They show on the whole a regular curve with its maximum in January and its minimum in July. There is a slight secondary maxi-

TABLE III.—Extreme Maximum Pressure for each Month and Year during the Twenty-three Years 1869 to 1891.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1869	30·329	30·462	30·418	30·258	30·317	30·413	30·410	30·469	30·530	30·580	30·561	30·563	30·580
1870	30·543	30·482	30·472	30·499	30·453	30·573	30·329	30·373	30·465	30·432	30·518	30·483	30·573
1871	30·268	30·505	30·562	30·244	30·390	30·405	30·194	30·485	30·316	30·374	30·295	30·497	30·562
1872	30·058	30·094	30·190	30·351	30·436	30·223	30·178	30·352	30·319	30·346	30·409	30·057	30·436
1873	29·981	30·728	30·196	30·445	30·374	30·394	30·188	30·247	30·520	30·499	30·480	30·574	30·728
1874	30·713	30·542	30·760	30·250	30·408	30·579	30·334	30·388	30·285	30·370	30·441	30·424	30·760
1875	30·439	30·594	30·613	30·604	30·438	30·271	30·467	30·302	30·336	30·487	30·350	30·545	30·613
1876	30·628	30·305	30·390	30·432	30·412	30·356	30·415	30·333	30·179	30·404	30·401	30·178	30·628
1877	30·415	30·279	30·280	30·282	30·327	30·253	30·350	30·189	30·449	30·660	30·413	30·656	30·660
1878	30·640	30·668	30·684	30·167	30·203	30·151	30·419	30·251	30·315	30·165	30·451	30·411	30·684
1879	30·533	30·321	30·491	30·366	30·583	30·127	30·132	30·332	30·426	30·521	30·715	30·620	30·715
1880	30·532	30·537	30·459	30·479	30·474	30·339	30·273	30·274	30·437	30·368	30·545	30·631	30·631
1881	30·457	30·388	30·556	30·303	30·652	30·363	30·227	30·344	30·368	30·478	30·217	30·543	30·652
1882	30·903	30·890	30·630	30·323	30·469	30·260	30·379	30·467	30·437	30·645	30·298	30·121	30·903
1883	30·311	30·815	30·777	30·560	30·437	30·470	30·297	30·325	30·309	30·533	30·505	30·697	30·815
1884	30·667	30·464	30·195	30·270	30·303	30·472	30·228	30·342	30·388	30·630	30·714	30·377	30·714
1885	30·336	30·164	30·577	30·319	30·235	30·370	30·387	30·268	30·351	30·269	30·171	30·639	30·639
1886	30·394	30·546	30·355	30·429	30·324	30·319	30·385	30·328	30·371	30·283	30·763	30·437	30·763
1887	30·688	30·593	30·592	30·534	30·510	30·467	30·440	30·359	30·544	30·673	30·332	30·449	30·688
1888	30·596	30·555	30·491	30·371	30·483	30·252	30·253	30·401	30·524	30·394	30·317	30·548	30·596
1889	30·696	30·543	30·571	30·289	30·086	30·505	30·516	30·258	30·410	30·214	30·572	30·654	30·696
1890	30·504	30·706	30·598	30·253	30·276	30·408	30·425	30·277	30·544	30·564	30·432	30·450	30·706
1891	30·940	30·756	30·650	30·351	30·356	30·431	30·312	30·322	30·354	30·497	30·649	30·504	30·940
Extremes for the 23 years.	30·940	30·890	30·777	30·604	30·652	30·579	30·516	30·485	30·544	30·673	30·763	30·697	30·940

TABLE IV.—Extreme Minimum Pressure for each Month and Year during the Twenty-three Years 1869 to 891

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1869	28·386	28·753	29·169	29·282	28·961	29·527	29·553	29·640	29·064	29·343	29·281	28·821	28·386
1870	28·516	28·726	29·082	29·063	28·743	29·783	29·689	29·520	29·114	28·795	28·802	28·540	28·516
1871	28.070*	29·018	28·922	28·893	29·594	29·337	29·450	29·321	28·931	28·888	29·532	29·011	28·070
1872	28·321	28·941	28·891	29·092	29·380	29·255	29·488	29·205	29·130	28·570	28·301	28·463	28·301
1873	28·270	28·675	28·827	29·428	29·328	29·441	29·354	29·193	29·203	28·915	28·991	29·137	28·270
1874	29·136	28·479	29·398	28·741	29·503	29·618	29·441	29·173	29·007	29·131	28·794	28·650	28·479
1875	28·606	29·319	29·072	29·031	29·149	29·073	29·423	29·566	29·301	29·031	28·835	29·179	28·606
1876	29·555	28·981	28·357	28·859	29·687	29·521	29·512	29·040	29·216	28·680	28·847	28·418	28·357
1877	28·324	29·467	28·707	28·845	28·925	29·053	29·202	28·863	29·366	28·949	28·325	29·125	28·324
1878	29·558	29·461	29·268	29·245	29·016	29·274	29·753	29·299	29·364	28·479	29·348	28·893	28·479
1879	29·127	28·639	29·182	28·864	29·605	29·128	29·116	29·171	29·283	29·582	29·939	29·538	28·639
1880	29·561	28·533	29·082	29·230	29·662	29·436	29·417	29·329	28·871	28·855	28·687	29·068	28·533
1881	28·642	28·945	28·919	29·422	29·294	29·068	29·350	29·105	29·230	28·690	28·445	28·977	28·445
1882	29·269	28·671	28·815	28·765	29·180	29·426	29·100	29·203	28·941	28·883	29·130	29·149	28·671
1883	28·814	28·708	28·956	28·911	29·378	29·462	29·264	29·281	28·463	28·941	28·656	29·634	28·463
1884	28·317	28·752	28·912	28·915	29·392	29·557	29·277	29·564	29·171	29·474	29·241	29·103	28·317
1885	28·420	28·618	29·002	28·694	29·200	29·538	29·661	29·098	29·235	29·038	28·559	29·175	28·420
1886	29·064	29·397	29·244	29·077	28·988	29·621	29·081	29·145	29·379	28·742	29·135	28·298	28·298
1887	28·866	29·432	29·010	29·115	29·404	29·621	29·241	29·287	28·893	28·885	28·412	28·999	28·412
1888	29·070	29·513	28·401	28·806	28·852	29·393	29·286	29·177	29·731	29·389	28·949	28·528	28·401
1889	29·122	29·437	28·840	29·173	29·286	29·361	29·494	29·182	29·414	29·036	29·126	29·369	28·840
1890	28·477	29·232	28·921	29·278	29·186	29·206	29·379	29·337	28·778	29·595	28·996	29·127	28·477
1891	29·235	29·708	28·896	29·194	29·232	29·169	29·533	28·901	29·157	28·344	28·341	28·951	28·341
Extremes for the 3 years.	28·070	28·479	28·357	28·694	28·743	29·053	29·081	28·863	28·463	28·344	28·301	28·298	28·070

* This was a reading of the Standard Barometer. The mercury had fallen below the slit illuminated by the burner, and the Barograph consequently failed to record the lowest point reached; standard readings were taken at frequent intervals, and apparently 28·070 in., the reading adopted, was very near the true minimum.

mum in November. The decrease of over half-an-inch (0·501 in.) in the amplitude from March to April is more marked than the increase in the autumn between August and September, which only amounts to 0·459 in.

As regards the actual extreme maximum pressures it will be noticed that in the whole interval of 23 years, in only one month, viz. January 1873, has the maximum been below 30 inches, the mercury rising to only 29·81 in. This was a particularly stormy period, no less than eight severe gales having been experienced in the month.

The minimum has been extraordinarily high in two of the months, viz. November 1879, 29·939 in., and June 1870, 29·783 in. The mercury has never fallen below 29 inches in either June or July during the whole period.

Temperature.

Table V. gives the mean monthly temperatures for the entire period of four lustra. The means for the four lustral intervals are given separately, and those for the 23 years at foot. The first three months exhibit a striking uniformity in the mean temperature, a feature which extends back to December. The figures are represented on Fig. 3, p. 271.

TABLE V.—Mean Monthly and Annual Temperature during the Twenty-three Years 1869 to 1891, with the Means for each Lustrum, and for the whole Period.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means
	°	°	°	°	°	°	°	°	°	°	°	°	°
1869	47·7	48·7	44·7	51·7	51·4	56·7	61·4	60·0	57·1	54·1	50·2	43·9	52·3
1870	44·3	41·7	45·6	49·7	52·3	57·7	60·8	61·6	58·7	53·7	46·5	40·8	51·1
1871	43·2	47·7	47·7	50·7	55·0	57·5	58·4	60·4	55·7	53·5	47·0	44·9	51·8
1872	45·7	47·2	47·5	48·5	50·7	55·1	59·7	59·6	57·2	49·7	47·0	46·3	51·2
1873	45·5	41·9	44·5	49·5	52·7	57·0	58·5	58·7	55·1	50·5	47·1	49·0	50·8
1874	46·3	46·5	47·9	49·8	53·3	58·0	60·0	59·3	55·7	52·3	49·4	43·5	51·8
1875	49·2	43·3	45·7	50·3	53·4	55·5	58·1	60·8	59·6	52·2	46·7	44·8	51·6
1876	45·7	46·5	43·9	48·5	51·9	55·4	59·8	60·2	55·9	54·0	49·7	47·0	51·5
1877	46·6	47·5	45·4	48·5	51·1	57·3	57·6	58·5	55·0	53·8	48·5	47·1	51·4
1878	47·0	47·8	47·4	50·1	53·3	56·9	62·0	61·1	58·1	53·2	43·9	39·3	51·7
1879	41·5	43·6	45·3	46·5	50·0	54·9	55·5	57·0	54·5	51·1	46·5	44·5	49·2
1880	44·3	46·3	48·5	48·5	53·0	56·6	58·9	62·8	59·4	47·1	47·6	46·5	51·6
1881	38·6	43·8	46·1	48·3	54·2	55·3	57·9	57·0	55·7	51·9	52·1	45·2	50·5
1882	47·7	47·8	48·3	49·1	53·2	55·3	57·1	58·4	53·9	51·5	47·5	43·7	51·1
1883	46·3	45·3	42·2	47·6	50·8	56·2	56·3	58·2	56·2	52·1	48·5	46·3	50·5
1884	47·9	46·0	46·5	47·7	53·0	55·6	58·8	58·9	57·4	51·9	46·1	45·6	51·3
1885	44·4	45·3	44·2	46·9	49·1	55·3	59·4	59·3	55·6	49·0	48·8	44·8	50·2
1886	41·9	43·4	43·5	48·2	50·6	56·9	59·0	58·9	57·1	52·6	48·6	43·3	50·3
1887	45·5	45·4	43·6	45·8	52·1	61·5	61·7	60·1	55·5	49·5	44·9	43·2	50·7
1888	45·0	40·6	41·6	46·3	52·2	57·0	57·1	58·7	55·4	52·2	49·5	47·0	50·2
1889	45·6	44·5	45·3	46·7	52·1	57·1	58·4	57·7	57·6	49·7	49·2	47·3	50·9
1890	46·3	43·4	45·4	48·3	52·3	55·5	56·8	57·3	58·0	54·4	47·4	41·4	50·5
1891	42·7	47·0	43·0	47·5	49·5	58·0	57·8	57·0	56·4	49·9	45·6	46·9	50·1
Means 1869–91	45·2	45·3	45·4	48·5	52·1	56·6	58·7	59·2	56·6	51·7	47·8	44·9	51·0
Means 1871–75	46·0	45·3	46·7	49·8	53·0	56·6	58·9	59·8	56·7	51·6	47·4	45·7	51·5
1876–80	45·0	46·3	46·1	48·4	51·9	56·2	58·8	59·9	56·6	51·8	47·2	44·9	51·1
1881–85	45·0	45·6	45·5	47·9	52·1	55·5	57·9	58·4	55·8	51·3	48·6	45·1	50·7
1886–90	44·9	43·5	43·9	47·1	51·9	57·6	58·6	58·5	56·7	51·7	47·9	44·4	50·5

A rise of 2°·7 occurs between March and April, and the curve continues to ascend briskly for the next two months. The rise then slackens, and the actual maximum of the monthly mean temperatures, 59°·2, appears in August. The descent is more uniform, and more rapid than the ascent had been, as in the space of four months the lowest point is again reached—in December—with a mean temperature of 45°·0.

It is somewhat remarkable that there are no clearly marked periods of either spring or autumn. Throughout the four months of winter the total change of mean monthly temperature does not exceed 0°·6, while no approach to such uniformity is noticeable at any other season. The maximum in August coincides with the known maximum in sea-surface temperature at the same month, but there is no corresponding coincidence of a minimum of air temperature in February, when the sea-surface is at its coldest.

TABLE VI.—MEAN HOURLY VALUES FOR AIR TEMPERATURE IN EACH MONTH DURING THE TWENTY YEARS 1871 TO 1890.

Hour.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means
	°	°	°	°	°	°	°	°	°	°	°	°	°
0	44·71	44·46	44·09	46·35	49·67	53·91	56·36	57·16	54·83	50·55	47·19	44·58	49·49
1	44·79	44·49	43·99	46·16	49·44	53·69	56·17	56·97	54·69	50·47	47·22	44·64	49·39
2	44·70	44·40	43·81	45·92	49·17	53·42	55·95	56·70	54·54	50·31	47·07	44·51	49·21
3	44·72	44·38	43·68	45·77	48·94	53·24	55·83	56·63	54·49	50·21	47·05	44·49	49·12
4	44·68	44·25	43·53	45·50	48·66	53·05	55·66	56·49	54·32	50·13	46·87	44·39	48·96
5	44·73	44·12	43·48	45·38	48·61	53·14	55·66	56·46	54·26	50·13	46·88	44·40	48·94
6	44·63	44·02	43·36	45·26	48·98	53·77	56·03	56·40	54·12	50·07	46·82	44·22	48·97
7	44·65	44·07	43·43	45·92	50·21	54·89	57·01	57·23	54·40	50·12	46·85	44·24	49·42
8	44·60	44·02	43·86	46·94	51·33	55·92	57·91	58·24	55·24	50·38	46·79	44·22	49·95
9	44·72	44·51	44·99	48·18	52·65	57·06	59·04	59·42	56·49	51·41	47·32	44·34	50·84
10	45·06	45·19	45·99	49·20	53·54	57·86	59·78	60·28	57·45	52·32	47·94	44·73	51·61
11	45·73	46·04	47·07	50·24	54·49	58·73	60·60	61·21	58·48	53·25	48·83	45·53	52·52
Noon	46·15	46·61	47·73	50·89	55·01	59·28	61·05	61·73	59·00	53·74	49·28	46·07	53·05
13	46·59	47·10	48·30	51·62	55·59	59·85	61·58	62·34	59·51	54·13	49·67	46·55	53·57
14	46·63	47·17	48·41	51·75	55·81	59·94	61·64	62·53	59·54	54·20	49·69	46·66	53·66
15	46·60	47·22	48·49	51·90	56·00	60·12	61·80	62·62	59·59	54·09	49·56	46·46	53·70
16	46·21	46·86	48·22	51·63	55·75	59·80	61·55	62·26	59·18	53·63	49·00	45·98	53·34
17	45·66	46·37	47·79	51·29	55·46	59·46	61·18	61·82	58·68	52·87	48·28	45·41	52·86
18	45·22	45·58	46·96	50·46	54·79	58·77	60·59	61·04	57·65	51·94	47·89	45·06	52·16
19	45·09	45·15	45·96	49·32	53·86	58·10	59·83	60·08	56·46	51·47	47·73	44·97	51·50
20	44·93	44·86	45·36	48·06	52·38	56·95	58·73	58·73	55·80	51·14	47·51	44·86	50·78
21	44·89	44·77	45·05	47·52	51·22	55·48	57·54	57·94	55·46	51·01	47·44	44·85	50·26
22	44·79	44·64	44·69	47·09	50·63	54·74	56·95	57·55	55·18	50·70	47·28	44·67	49·91
23	44·80	44·56	44·45	46·78	50·26	54·34	56·66	57·36	55·02	50·57	47·20	44·73	49·73
Midnt.	44·67	44·40	44·13	46·44	49·83	54·02	56·38	57·14	54·77	50·41	47·06	44·59	49·49
Means	45·20	45·17	45·47	48·22	52·09	56·38	58·46	59·05	56·37	51·57	47·78	45·01	50·90

If we examine the annual means we find that the highest figure is 51°·8, occurring in 1871 and 1874, while the lowest is 49°·2 in 1879, giving a range in the mean temperature of the 20 consecutive years of only 2°·6.

Let us now examine the values for the individual months. The mean value of 60° has been attained or exceeded in the 23 years once in June, five times in July, and eight times in August. The mean has fallen below 40° only twice, viz. in January 1881, and in December 1878. These few words are sufficient to show the uniformity of the mean temperature of the station.

Diurnal Range of Temperature.

In addition to what has already been said on this subject, under the head of Pressure, reference may be made to a careful discussion of the results of the harmonic analysis of the temperature observations which appeared in the *Philosophical Transactions* for 1893, pp. 617-646, from the pen of Lieut.-Gen. R. Strachey, F.R.S., Chairman of the Meteorological Council.

Table VI. is precisely similar in arrangement to Table II., and it gives for the four lustra, and for the 20 years 1871-90, the mean hourly values of temperature in the several months.

TABLE VII.—MEAN MONTHLY AND ANNUAL MAXIMUM TEMPERATURE DURING THE TWENTY-THREE YEARS 1869 TO 1891, WITH THE MEANS FOR EACH LUSTRUM, AND FOR THE WHOLE PERIOD.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means
	°	°	°	°	°	°	°	°	°	°	°	°	°
1869	50·5	51·3	49·1	56·1	56·8	62·5	66·3	66·3	61·3	57·9	53·3	47·6	56·6
1870	47·3	45·3	50·4	54·7	56·6	62·6	66·3	67·9	64·4	58·2	49·9	44·2	55·7
1871	46·6	50·6	52·3	55·0	61·4	63·1	62·8	65·6	61·4	57·2	50·1	48·8	56·2
1872	48·7	50·4	51·3	53·2	55·7	59·2	64·5	64·3	60·7	53·4	50·3	49·4	55·1
1873	48·5	46·1	49·1	55·0	57·9	62·0	63·2	63·1	59·7	54·6	50·4	51·3	55·1
1874	49·6	49·6	51·3	54·8	59·4	64·0	64·8	64·1	59·9	55·7	52·3	47·5	56·1
1875	51·6	47·0	49·4	56·0	58·2	60·4	63·6	65·7	64·6	56·1	50·2	48·2	55·9
1876	49·0	49·9	48·5	53·2	59·0	60·7	65·7	65·2	59·8	57·4	53·4	50·2	56·0
1877	50·4	50·4	49·6	53·3	57·2	62·9	61·7	63·1	60·8	57·7	51·9	50·3	55·8
1878	49·7	51·1	51·4	55·2	58·0	62·1	67·6	65·9	62·3	56·9	48·3	43·8	56·0
1879	45·1	47·4	49·8	51·4	54·8	59·9	60·2	62·0	58·2	55·4	49·5	48·3	53·5
1880	46·9	49·7	53·2	53·6	58·9	61·9	64·2	69·8	63·6	52·9	51·2	49·5	56·3
1881	42·7	47·3	50·4	54·3	60·4	60·1	62·5	61·6	61·1	55·7	55·3	49·2	55·1
1882	50·7	50·9	52·0	54·3	59·2	60·5	61·4	63·7	58·6	55·7	50·7	47·1	55·4
1883	49·6	49·2	47·3	53·6	56·2	61·6	60·4	62·8	60·5	56·1	52·1	49·5	54·9
1884	50·7	49·4	50·3	53·0	58·4	61·3	63·7	63·5	61·8	56·0	50·0	49·0	55·6
1885	47·4	48·7	49·1	52·3	53·9	61·1	65·4	65·6	59·9	52·5	51·6	48·0	54·6
1886	45·5	46·9	47·3	53·6	55·7	62·3	63·7	63·2	61·1	56·7	51·5	46·6	54·5
1887	48·6	48·8	48·8	52·2	57·4	69·4	66·7	65·6	61·0	53·7	48·7	46·6	55·6
1888	48·0	44·2	46·5	50·4	57·9	62·7	62·1	63·9	61·2	56·3	52·4	50·4	54·7
1889	48·5	48·0	49·6	51·5	56·6	62·8	64·4	61·4	61·7	54·2	52·1	50·2	56·1
1890	50·2	47·4	49·6	52·9	57·6	59·9	60·9	62·2	61·8	57·7	51·3	44·8	54·7
1891	46·5	50·6	47·9	52·8	55·1	64·3	62·7	61·0	60·5	53·7	49·3	50·1	54·5
Means 1869–75	48·4	48·7	49·7	53·6	57·5	62·5	63·7	64·2	61·1	55·7	51·1	48·3	55·3
Means 1871–75	49·0	48·7	50·7	54·8	58·5	61·7	63·8	64·6	61·3	55·4	50·7	49·0	55·7
1876–80	48·2	49·7	50·5	53·3	57·6	61·5	63·9	65·2	60·9	56·1	50·9	48·4	55·5
1881–85	48·2	49·1	49·8	53·5	57·6	60·9	62·7	63·4	60·4	55·2	51·9	48·6	55·1
1886–90	48·2	47·1	48·4	52·1	57·0	63·4	63·6	63·3	61·4	55·7	51·2	47·7	54·9

In Tables VII. and VIII. (p. 278) the monthly maximum and minimum temperatures are given for the series of 23 years. These two curves follow much the same course as that for the mean monthly temperature, and in each case the descending branch is steeper than the ascending. We find almost the same unchangeableness of extreme temperatures in the winter as existed in the mean temperatures. As regards the extreme minima, it is remarkable that they are lowest in March and December.

In Tables IX. and X. the monthly extremes of temperature are given. It will be seen from Table IX. that the highest temperature ever recorded was 82°·3 on August 7, 1869, and that on only three occasions during the 23 years was the temperature of 80° attained, viz. on August 7, 1869, on July 22, 1878, and on June 19, 1887. Temperatures between 75° and 80° have been recorded ten times. The monthly maximum has never fallen below 50°, but the maxima in the three winter months are rarely so high as 55°; for this temperature has only been recorded twice in January, once in February, and four times in December; while the maximum was below 55° seven times in March, once in April, and three times in November.

TABLE VIII.—Mean Monthly and Annual Minimum Temperature during the Twenty-three Years 1869 to 1891, with the Means for each Lustrum, and for the Whole Period.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means
	°	°	°	°	°	°	°	°	°	°	°	°	°
1869	44·1	45·2	39·9	47·7	47·0	51·8	56·6	54·1	52·5	50·6	46·3	39·7	48·0
1870	40·4	37·9	40·9	45·1	48·5	54·0	56·3	55·2	53·6	48·2	42·8	36·9	46·7
1871	39·4	44·2	42·8	47·2	49·0	52·6	54·2	56·1	50·1	49·1	43·3	40·5	47·4
1872	41·5	43·5	43·9	44·1	45·9	51·6	55·9	55·1	53·6	45·2	42·6	41·9	47·1
1873	41·8	38·2	40·3	45·3	48·4	53·0	55·0	55·3	51·6	46·3	42·4	45·8	47·0
1874	42·3	43·0	44·2	45·0	47·8	52·1	55·8	54·8	51·3	48·2	45·9	39·1	47·5
1875	45·9	39·6	41·7	45·5	48·5	51·2	53·7	56·0	54·6	47·6	42·3	40·7	47·3
1876	41·7	42·5	38·4	44·2	45·5	50·7	53·9	55·6	52·5	50·5	46·0	43·2	47·1
1877	41·5	43·5	41·1	44·5	45·3	52·3	53·8	54·3	50·1	49·3	44·2	43·1	46·9
1878	43·4	44·8	43·2	45·5	48·8	52·1	57·0	56·5	53·4	49·0	39·0	34·8	47·3
1879	37·4	39·9	40·7	42·4	45·1	50·4	51·7	52·6	50·8	46·6	42·7	40·1	45·0
1880	41·0	41·9	44·4	43·2	47·5	51·7	54·1	57·3	55·7	41·5	43·0	43·1	47·0
1881	34·7	39·5	41·8	42·8	48·0	50·6	53·8	52·6	50·6	48·2	47·9	40·5	45·9
1882	44·2	44·1	43·8	44·3	47·3	50·6	53·0	53·6	49·1	46·7	42·5	39·5	46·6
1883	42·1	40·2	37·2	41·6	45·4	51·0	52·8	54·2	51·9	47·5	44·2	42·3	45·9
1884	44·2	42·1	42·0	42·8	47·6	49·6	54·5	54·9	53·2	47·5	41·1	41·3	46·7
1885	40·9	41·2	39·1	41·8	44·9	49·9	54·4	53·5	51·0	44·6	45·6	40·8	45·6
1886	37·6	40·0	39·4	42·9	45·8	52·1	54·2	55·1	52·8	47·7	44·5	38·6	45·9
1887	41·4	41·0	38·3	39·8	46·4	54·0	56·5	55·4	50·7	44·9	39·8	38·5	45·6
1888	41·4	37·1	36·6	42·0	46·7	52·2	53·0	53·8	49·9	47·9	46·0	42·8	45·8
1889	41·4	40·0	41·4	41·6	48·1	51·7	52·8	54·3	54·2	45·1	46·2	43·2	46·7
1890	41·4	39·1	40·4	43·8	47·5	51·9	52·8	52·4	54·4	50·5	43·1	37·5	46·2
1891	38·3	43·4	37·9	42·2	44·3	52·3	53·3	53·4	52·3	45·4	41·2	42·6	45·6
Means 1869–91	41·2	41·4	40·8	43·7	46·9	51·7	54·3	54·6	52·2	47·3	43·6	40·7	46·5
Means 1871–75	42·2	41·7	42·6	45·4	47·9	52·1	54·9	55·5	52·2	47·3	43·3	41·6	47·2
1876–80	41·0	42·5	41·6	44·0	46·4	51·4	54·1	55·3	52·5	47·4	43·0	40·9	46·7
1881–85	41·2	41·4	40·8	42·7	46·6	50·3	53·7	53·8	51·2	46·9	44·3	40·9	46·2
1886–90	40·6	39·4	39·2	42·0	46·9	52·4	53·9	54·2	52·4	47·2	43·9	40·1	46·0

The extreme minima in the several months are shown in Table X. It will be seen that the temperature never fell below 40° in April 1871, and that in twelve years it never fell to that point in May. Throughout the three succeeding months no temperature lower than 41° was ever recorded, and, with the exceptions of 1871 and 1885, the same may be said of September. In five years the minimum in October was above 40°; six times for July, and six times for August has the thermometer never fallen to 50°, while from November to April, with one exception already mentioned, the minimum never rose to 40°.

TABLE IX.—EXTREME MAXIMUM TEMPERATURES FOR EACH MONTH AND YEAR DURING THE TWENTY-THREE YEARS 1869 TO 1891.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1869	53·7	54·6	53·4	69·6	63·4	74·3	77·9	82·3	68·4	73·4	57·4	55·0	82·3
1870	53·2	52·3	57·6	61·5	65·6	73·5	79·6	77·6	71·0	68·3	56·5	52·7	79·6
1871	51·3	52·9	64·2	58·7	72·9	69·4	66·7	71·2	70·5	62·2	58·1	54·5	72·9
1872	53·6	53·3	55·7	59·9	64·8	66·2	69·7	75·5	68·0	58·1	59·0	54·0	75·5
1873	52·7	50·5	56·8	65·8	68·0	68·5	71·8	68·2	63·4	62·5	55·0	54·6	71·8
1874	54·0	53·2	59·0	66·6	66·8	71·9	73·3	80·1	64·3	59·8	56·0	53·0	80·1
1875	54·7	53·3	56·2	66·1	69·3	74·3	72·6	72·5	72·3	61·4	58·5	54·5	74·3
1876	55·0	53·9	54·0	59·5	66·1	74·6	79·5	78·5	64·2	62·6	59·3	54·8	79·5
1877	53·4	54·1	55·7	59·7	62·0	74·4	67·3	71·5	67·0	64·4	56·1	54·1	74·4
1878	55·1	55·2	55·9	63·4	63·8	69·0	80·1	74·3	69·0	64·6	53·8	53·5	80·1
1879	52·4	51·8	55·7	56·1	59·1	66·1	64·9	67·4	61·2	63·6	56·6	55·3	67·4
1880	54·6	53·0	59·1	59·8	71·9	72·8	71·3	77·2	72·2	65·6	56·4	54·4	77·2
1881	51·0	54·3	54·9	61·3	73·0	71·7	67·9	65·5	64·6	62·9	61·5	54·1	73·0
1882	54·4	53·3	56·6	62·0	66·5	72·0	64·1	73·6	62·6	61·4	56·6	54·5	73·6
1883	54·1	52·9	56·9	60·3	63·9	71·6	64·7	68·1	65·6	61·4	56·5	54·0	71·6
1884	54·6	54·0	55·8	57·6	73·0	69·5	69·6	68·0	70·9	61·4	55·5	55·6	73·0
1885	53·3	54·3	53·6	57·6	58·7	69·4	77·0	75·9	64·9	57·1	56·5	53·8	77·0
1886	52·6	52·6	55·2	67·0	64·4	73·3	73·3	68·0	66·1	64·9	56·5	53·4	73·3
1887	53·6	52·9	57·1	59·6	67·7	80·6	71·4	70·7	65·5	59·5	53·2	53·6	80·6
1888	53·4	50·3	52·0	54·2	69·0	73·2	67·0	70·4	65·0	61·4	57·2	55·7	73·2
1889	52·8	53·2	54·0	53·6	62·0	70·0	72·6	65·6	70·6	59·1	56·2	53·7	72·6
1890	54·3	51·9	58·5	57·9	70·7	67·0	63·6	73·5	68·0	62·3	57·6	53·1	73·5
1891	51·9	56·7	52·5	58·3	65·7	78·2	72·0	64·2	71·7	59·1	53·9	54·0	78·2
Extremes for the 23 years.	55·1	56·7	64·2	69·6	73·0	80·6	80·1	82·3	72·3	73·4	61·5	55·6	82·3

TABLE X.—EXTREME MINIMUM TEMPERATURES FOR EACH MONTH AND YEAR DURING THE TWENTY-THREE YEARS 1869 TO 1891.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1869	37·0	39·1	34·4	37·4	40·1	45·8	50·7	48·1	45·6	42·4	35·7	27·7	27·7
1870	31·3	30·3	34·4	37·8	40·7	49·0	51·2	46·2	45·2	39·0	33·8	27·2	27·2
1871	31·4	35·8	34·3	40·0	42·3	46·3	50·3	51·0	39·0	38·7	33·8	30·4	30·4
1872	34·7	38·8	31·4	34·1	40·0	45·0	48·6	47·8	44·0	38·0	32·2	33·4	31·4
1873	31·4	25·2	34·3	36·4	40·9	45·9	48·8	51·0	42·0	35·5	35·0	34·4	25·2
1874	35·0	37·5	29·0	35·3	38·5	47·0	47·8	50·0	44·8	41·2	37·0	32·0	29·0
1875	32·7	32·7	33·6	37·1	41·0	45·9	49·1	48·4	48·0	40·8	33·7	30·1	30·1
1876	31·0	32·4	30·9	33·3	38·2	44·8	46·2	48·0	47·0	38·3	35·3	34·4	30·9
1877	33·4	33·4	34·0	37·6	37·0	47·3	48·4	45·5	42·5	39·3	38·7	37·8	33·4
1878	32·1	33·4	35·8	35·6	43·9	45·8	51·8	52·7	47·5	35·2	33·1	27·4	27·4
1879	28·6	31·2	31·9	32·1	37·9	41·9	48·3	47·9	45·5	37·4	35·2	29·4	28·6
1880	31·0	35·9	37·0	38·0	40·6	42·5	47·9	50·1	49·5	32·9	29·7	33·4	29·7
1881	24·6	30·6	31·0	31·9	40·2	43·7	50·1	45·9	44·9	35·0	39·7	30·6	24·6
1882	33·8	36·6	35·2	37·5	38·4	42·6	46·9	47·7	42·8	39·8	33·9	29·1	29·1
1883	34·2	33·9	29·5	35·6	37·2	45·3	46·9	50·7	44·6	41·3	38·6	31·3	29·5
1884	33·0	33·6	31·0	35·6	39·7	44·0	48·0	48·8	49·0	40·4	31·6	33·9	31·0
1885	31·8	33·0	32·7	35·7	36·7	44·5	44·8	48·7	40·1	38·3	34·2	30·5	30·5
1886	28·2	31·9	29·0	35·7	38·6	49·4	48·6	48·2	43·6	36·5	36·6	26·8	26·8
1887	35·1	30·0	30·4	34·0	37·7	47·8	50·8	46·7	44·4	32·9	30·6	30·3	30·0
1888	30·0	26·8	30·0	34·4	40·2	46·4	48·4	46·0	43·7	38·8	37·4	32·1	26·8
1889	30·4	33·4	32·5	35·2	41·0	44·6	46·8	49·5	49·0	38·0	33·9	34·4	30·4
1890	30·7	31·7	30·2	36·5	40·7	47·9	46·8	42·9	48·8	39·5	28·7	29·4	28·7
1891	30·0	33·6	28·7	35·5	38·6	42·3	47·4	46·8	44·7	35·0	33·1	32·6	28·7
Extremes for the 23 years.	24·6	25·2	28·7	31·9	36·7	41·9	44·8	42·9	39·0	32·9	28·7	26·8	24·6

The number of times the minimum was below the freezing-point was comparatively small. This occurred in the month of January in 13 years, in February in 8, in March in 12, in April in 1, in November in 4, and in December in 14 years.

The fact is interesting that in only one year was a temperature below 32° recorded in April, and then only for a few minutes. This occurred at 6h. 5m. a.m. on April 3, 1881, during a strong East wind, which amounted to a gale in some places. At 8 a.m. the same morning no temperature as high as 40° was reported to the Meteorological Office from any British station excepting Jersey. The extreme rarity of the occurrence of a freezing temperature in April goes far to prove the immunity of Valencia from spring frosts, so deleterious to vegetation; but in the absence of any grass minimum temperatures, it is impossible to assert that these do not occur, for the thermometer "on grass" frequently falls several degrees below that at the height of 12 feet, which was the elevation of the thermograph instrument.

The absolute minimum ever recorded was 24°·6 on January 21, 1881, the next to it being 25°·2 on February 3, 1873.

Before quitting the subject of temperature, it should be noted that the variability of the diurnal temperature has been discussed by Mr. R. H. Scott, F.R.S., in the *Proceedings of the Royal Society*, vol. xlvii. pp. 303-363. The period to which this paper refers is not conterminous with that to which the tables embodied in the present paper refer, inasmuch as Mr. Scott took in only 15 years, 1869-83. The paper refers to the seven observatories originally started by the Meteorological Office, and the method followed in it was "to extract the differences between the successive daily means, irrespective of sign, and then to take the average of the figures so obtained for each month."

The following are the values of the mean variability for each month:—

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
2°·6	2°·1	2°·1	1°·8	1°·5	1°·4	1°·3	1°·4	1°·6	2°·1	2°·3	2°·7	1°·9

These figures show in the most convincing way the extreme equability of the climate of Valencia.

The actual figures were also examined with the view of ascertaining if in cases of considerable change, *i.e.* of over 5° between two successive means, the motion was in the direction of rising or of falling. The result was that as regards changes of 5°, the rises and falls were exactly balanced, 167 cases of each being noticed, but the mean amount of rise was 6°·7, while the mean amount of fall was 6°·2. There were during the 15 years only three instances of rise exceeding 10°, and one of rise exceeding 15°. There was only one instance of fall exceeding 10°.

Mr. Scott's paper concludes with a table showing the number of occasions in each month, and in each year, of which the temperature reached definite limits.

No instance occurred of a mean daily temperature falling below 20°, and only five instances in January, one in February, and three in December of temperatures below 32°. Even in January there were 23 days with a temperature between 40° and 50°. At the other end of the scale there was only a single instance of a mean temperature exceeding 70°, in August 1869. With very rare exceptions, in June, July, and August, the temperature ranged between 50° and 70°.

The only one of the six remaining observatories which rivals Valencia as regards equability of temperature is Falmouth, but the frosty days there are decidedly more frequent. Both stations evince most clearly the influence of the Atlantic Ocean on their climates.

Vapour Tension.

The vapour tension results are given in Table XI. The figures (Fig. 3, p. 271) show an annual march bearing a great general resemblance to that for temperature, but the minimum is decidedly in March; the second minimum in December being very slight. The maximum is in August. Only twice has the monthly mean fallen below 0·2 in., viz. in December 1870, 0·199 in., and in January 1881, 0·198 in. The highest vapour tension was that for August 1880, which reached 0·480 in.

TABLE XI.—MEAN MONTHLY AND ANNUAL VAPOUR TENSION DURING THE YEARS 1869 TO 1891, WITH THE MEANS FOR EACH LUSTRUM, AND FOR THE WHOLE PERIOD.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1869	·274	·277	·222	·305	·291	·361	·441	·411	·374	·344	·299	·230	·319
1870	·229	·207	·250	·281	·321	·395	·465	·420	·400	·335	·257	·199	·313
1871	·232	·287	·258	·300	·318	·372	·402	·438	·343	·334	·255	·234	·314
1872	·249	·264	·269	·270	·284	·361	·436	·417	·389	·286	·264	·261	·313
1873	·249	·210	·235	·271	·310	·380	·409	·408	·348	·314	·267	·296	·308
1874	·263	·263	·275	·282	·311	·365	·412	·400	·358	·312	·303	·233	·315
1875	·310	·248	·245	·270	·315	·365	·387	·436	·422	·337	·259	·245	·320
1876	·262	·261	·225	·283	·284	·348	·406	·417	·371	·350	·306	·271	·315
1877	·260	·278	·249	·285	·296	·388	·395	·409	·349	·342	·279	·274	·317
1878	·277	·286	·270	·299	·323	·384	·462	·447	·403	·338	·231	·209	·327
1879	·221	·240	·248	·259	·282	·358	·378	·391	·360	·325	·253	·243	·296
1880	·243	·265	·285	·266	·299	·370	·406	·480	·422	·261	·275	·272	·320
1881	·198	·244	·251	·257	·320	·359	·414	·399	·378	·316	·322	·245	·309
1882	·281	·281	·276	·277	·311	·356	·404	·415	·340	·315	·263	·246	·314
1883	·259	·254	·209	·257	·290	·365	·390	·424	·391	·334	·281	·259	·309
1884	·277	·257	·255	·252	·317	·367	·410	·405	·384	·331	·264	·246	·314
1885	·246	·250	·232	·258	·273	·349	·425	·403	·357	·274	·293	·247	·301
1886	·219	·245	·233	·261	·296	·378	·407	·432	·379	·327	·287	·233	·308
1887	·250	·251	·222	·233	·312	·413	·443	·416	·354	·285	·251	·236	·306
1888	·264	·212	·218	·261	·313	·383	·384	·409	·363	·326	·302	·282	·310
1889	·271	·249	·254	·259	·339	·368	·378	·387	·385	·281	·301	·273	·312
1890	·261	·232	·248	·274	·320	·381	·394	·385	·427	·362	·275	·222	·315
1891	·230	·271	·213	·252	·279	·385	·386	·394	·388	·286	·250	·274	·301
Means 1869–91	·253	·254	·245	·270	·305	·372	·410	·415	·378	·318	·276	·249	·312
Means 1871–75	·261	·254	·256	·279	·308	·369	·409	·420	·372	·317	·270	·254	·314
1876–80	·253	·266	·255	·278	·297	·370	·409	·429	·381	·323	·269	·254	·315
1881–85	·252	·257	·245	·260	·302	·359	·409	·409	·370	·314	·285	·249	·309
1886–90	·253	·238	·235	·258	·316	·385	·401	·406	·382	·316	·283	·249	·310

Relative Humidity.

The relative humidity figures in Table XII. are decidedly high, not one of the annual means falling below 84, while the results for 1888 and 1890 were both 86.

The minimum of the monthly means (Fig. 3, p. 271) is in May, and is 78, and the maximum in winter, with 85 for January and February. The lowest figure is 74 for April 1876 and 1880, and the maximum 93 for January 1889.

TABLE XII.—Mean Monthly and Annual Relative Humidity during the Twenty-three Years 1869 to 1891, with the Means for each Lustrum, and for the whole Period.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means
	%	%	%	%	%	%	%	%	%	%	%	%	%
1869	85	82	77	80	77	79	81	80	80	81	84	81	81
1870	81	79	83	81	82	84	89	78	83	83	82	78	82
1871	83	87	79	81	74	79	82	84	77	81	80	79	81
1872	82	82	83	79	77	83	86	82	83	81	83	84	82
1873	83	80	79	77	78	82	84	83	80	86	83	85	82
1874	85	84	84	79	76	76	80	79	81	79	86	82	81
1875	89	88	80	74	77	83	79	82	83	86	82	83	82
1876	86	84	78	84	74	80	79	80	83	84	86	85	82
1877	83	86	83	84	79	83	83	84	81	82	82	85	83
1878	87	86	83	83	79	83	83	83	82	83	80	88	83
1879	85	84	82	83	79	80	86	84	85	86	81	83	84
1880	83	85	83	78	74	84	81	84	84	81	84	86	82
1881	85	85	81	76	76	82	86	86	85	82	82	82	82
1882	85	85	82	79	77	81	86	85	82	82	81	86	83
1883	83	84	78	79	78	81	86	87	87	85	83	83	83
1884	84	83	82	77	79	82	83	82	81	86	85	80	82
1885	84	83	80	81	78	80	85	80	80	78	85	83	81
1886	83	87	82	78	80	82	82	88	82	82	84	83	83
1887	86	86	82	82	81	79	84	81	83	84	90	86	84
1888	89	89	87	86	81	82	83	86	85	84	89	88	86
1889	93	88	86	87	87	79	79	85	84	83	87	87	85
1890	86	85	84	83	83	89	90	83	88	87	87	88	86
1891	89	85	77	80	82	80	85	85	88	85	86	91	84
Means 1869–91	85	85	82	80	79	81	84	83	83	83	84	84	83
Means 1871–75	84	84	81	78	76	81	82	82	81	83	83	83	82
1876–80	85	85	82	82	77	82	82	83	83	83	83	85	83
1881–85	84	84	81	78	78	81	85	84	83	83	83	83	82
1886–90	87	87	84	83	82	82	84	85	84	84	87	86	85

Rain.

The self-recording rain-gauge was not supplied to Valencia at the first starting of the observatory, as it was not until the end of the year 1870 that the instrument was perfected and declared ready for issue, so that the records from it do not commence till April 1871. For the earlier period, the figures are taken from the readings of an ordinary 8-inch gauge, placed close to the site of the automatic gauge. The figures for amount are given in Table XIII. p. 283, and those for number of days of rain in Table XIV. p. 284.

The curve for the 20 years is a very simple one, with a maximum of 6·45 in. in January, and a minimum of 3·29 in. in May. There is a decided indication of a second minimum in September, but the figures suffice to show that, without controversy, Valencia belongs to the region of winter rains. The average yearly amount for the four lustra is 58·26 in., and the number of days of rain (limit 0·005 in.) is 248. The wettest

year of the period was 1877, with 68·67 in. falling in 288 days, and the driest year 1887, with 43·74 in. falling in 194 days. The wettest month during the period was November 1877, with 10·44 in., and February 1883 came very near it with 10·42 in. The driest month was May 1876, with 0·70 in., and only 9 days of rain. There is only one other month in which less than an inch fell, viz. November 1879, with 0·85 in. in 10 days. On five occasions less than 10 days of rain were recorded, viz. May 1871 and June 1887, with 7 days each, August 1869, April 1875, and May 1876 (already mentioned), with 9 days each. In three instances, February 1869 and January and November 1877, rain was recorded on every day in the month, while in January 1875 and in February 1880, only one day was exempt.

TABLE XIII.—MONTHLY AND ANNUAL RAINFALL DURING THE TWENTY-THREE YEARS 1869 TO 1891, AND THE MEAN MONTHLY VALUES FOR EACH LUSTRUM, AND FOR THE WHOLE PERIOD.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1869	9·36	4·53	3·55	4·12	2·79	1·06	3·89	1·89	8·05	2·65	4·19	8·47	54·55
1870	6·82	5·67	2·24	2·83	4·48	0·59	2·29	2·52	4·13	8·20	5·38	3·61	48·76
1871	5·34	5·67	4·93	5·06	1·72	5·00	5·57	2·74	2·58	7·20	4·33	5·45	55·59
1872	8·51	7·14	4·26	1·62	2·09	6·28	5·58	4·50	4·78	8·14	6·97	8·29	68·16
1873	9·81	3·27	4·45	2·36	3·28	2·81	8·70	5·76	5·63	6·47	4·39	2·56	59·49
1874	4·98	6·23	5·60	4·23	1·26	2·01	4·42	5·41	5·72	7·23	4·50	7·45	59·04
1875	9·52	2·21	2·24	3·72	4·47	5·64	1·96	3·61	9·95	7·58	4·35	4·31	59·56
1876	4·48	5·79	5·33	4·00	0·70	2·73	2·70	4·98	6·24	5·61	9·31	9·58	61·45
1877	8·96	3·66	4·71	5·78	3·46	4·21	2·87	6·68	3·48	7·35	10·44	7·07	68·67
1878	5·62	3·39	1·86	3·82	6·37	5·52	1·98	6·51	3·84	6·61	3·48	4·28	53·28
1879	7·38	6·99	2·76	5·42	2·94	7·16	4·24	5·42	4·78	2·21	0·85	3·09	53·24
1880	4·25	6·84	3·01	4·96	2·41	4·84	3·98	4·89	4·62	2·50	6·08	5·32	53·70
1881	2·01	6·25	5·58	1·82	2·50	7·20	2·66	5·14	2·98	4·46	8·34	9·43	58·37
1882	4·55	5·13	3·37	6·73	1·39	4·23	7·17	4·92	3·87	9·56	7·72	5·86	64·50
1883	8·26	10·42	2·62	4·28	3·38	1·85	5·17	5·81	4·86	4·52	6·84	2·53	60·54
1884	6·24	9·27	10·35	2·65	3·09	1·47	7·11	4·27	3·84	4·42	5·23	5·82	63·76
1885	7·01	6·58	5·14	5·11	4·11	1·51	2·75	3·53	8·13	5·16	4·90	2·75	56·68
1886	5·46	5·86	6·37	3·10	5·37	1·31	5·96	5·36	4·06	7·76	4·82	7·41	62·84
1887	7·19	2·89	2·26	1·85	1·63	1·39	3·00	4·61	3·91	4·42	5·46	5·13	43·74
1888	4·30	1·83	4·68	2·92	3·74	3·55	4·29	5·06	1·77	2·85	3·80	9·08	47·87
1889	8·08	4·49	3·36	2·74	6·31	1·81	2·19	7·48	3·43	5·86	3·98	7·08	56·81
1890	7·01	3·48	4·29	5·19	5·61	6·25	3·95	2·85	3·19	4·00	7·49	4·65	57·96
1891	4·31	0·70	2·89	3·80	4·11	4·69	2·02	6·27	6·14	10·54	4·76	9·28	59·51
Means 1869–91	6·50	5·14	41·7	3·85	3·36	3·61	4·11	4·79	4·78	5·88	5·55	6·02	57·74
Means 1871–75	7·63	4·90	4·30	3·40	2·56	4·35	5·25	4·40	5·73	7·32	4·91	5·61	60·36
1876–80	6·14	5·33	3·53	4·80	3·18	4·89	3·15	5·70	4·59	4·86	6·03	5·87	58·07
1881–85	5·61	7·53	5·41	4·12	2·89	3·25	4·97	4·73	4·74	5·62	6·61	5·28	60·76
1886–90	6·41	3·71	4·19	3·16	4·53	2·86	3·88	5·07	3·27	4·98	5·11	6·67	53·84

The diurnal range of rainfall for the 10 years, 1871-80, has been discussed by Mr. R. H. Scott in a paper published as an appendix to the *Quarterly Weather Report* of 1877. In that paper all the seven observatories are dealt with. During the decade there was no loss of hourly measurements at Valencia owing to snow, but the gauge was out of order for four months in the spring 1872.

The figures for the seasons and for the year are reproduced in Table XV. (p. 285), both for quantity and for frequency. The figures given have been subjected to simple smoothing by the formula

$$B = \frac{a + 2b + c}{4}.$$

The figures for quantity show a decided maximum in the early morning hours, 4 to 6 a.m., and a minimum at 2 to 3 p.m., especially marked in summer, with a tendency at the same season for a secondary maximum at 6 p.m. Those for frequency exhibit a very striking march, with a maximum in the early morning, and a minimum about mid-day. The maximum falls decidedly earlier in summer than in winter. The original paper gives curves for the individual months in which the variations from month to month are clearly seen.

TABLE XIV.—NUMBER OF DAYS OF RAIN, MONTHLY AND ANNUAL, DURING THE TWENTY-THREE YEARS 1869 TO 1891, AND MEANS FOR EACH LUSTRUM, AND FOR THE WHOLE PERIOD.

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1869	27	28	17	22	20	12	17	9	23	26	26	23	250
1870	21	16	15	18	21	13	17	14	18	23	21	12	209
1871	21	22	15	22	7	14	26	13	12	25	14	21	212
1872	28	26	23	20	17	23	20	16	24	23	24	29	273
1873	27	13	21	14	18	18	24	29	19	24	21	20	248
1874	23	24	24	19	17	13	25	22	22	25	25	29	268
1875	30	15	11	9	20	24	13	18	20	30	17	20	227
1876	21	26	26	20	9	20	14	22	23	22	24	29	256
1877	31	26	24	24	16	21	26	26	15	21	30	28	288
1878	25	20	18	20	23	22	13	28	25	25	21	24	264
1879	20	25	19	21	18	25	25	23	24	18	10	15	243
1880	15	28	18	17	14	15	17	18	20	15	23	26	226
1881	15	19	18	16	10	22	23	24	17	19	28	26	237
1882	18	21	26	24	13	25	29	21	21	22	28	23	271
1883	28	25	16	19	15	17	27	22	22	24	27	20	262
1884	26	26	27	20	17	12	26	23	24	27	18	23	269
1885	26	23	19	22	25	11	12	15	27	24	23	22	249
1886	22	22	21	16	24	16	24	25	21	22	24	28	265
1887	24	15	11	10	13	7	22	20	19	10	20	23	194
1888	19	19	23	15	17	20	23	18	16	22	24	21	237
1889	21	24	18	18	25	11	17	25	17	21	21	26	244
1890	26	16	20	22	23	24	20	19	19	21	25	14	249
1891	21	12	19	14	22	17	17	26	20	23	21	24	236
Means 1869–91	23	21	20	18	18	17	21	21	20	22	22	23	246
Means													
1871–75	26	20	19	17	16	18	22	20	19	25	20	24	246
1876–80	22	25	21	20	16	21	19	23	21	20	22	24	254
1881–85	23	23	21	20	16	17	23	21	22	23	25	23	257
1886–90	22	19	19	16	20	16	21	21	18	19	23	22	236

Snow and Hail.

It will be most convenient to treat of the occurrences of snow and hail together. Both belong, almost exclusively, to the winter season. The figures are taken from the telegraphic reports, as being more detailed

than the weather registry kept at the observatory. The limited staff at the latter had their time pretty fully occupied with the work of keeping the instruments in action, as well as of measuring and tabulating their records numerically.

TABLE XV.—Diurnal Range of the Amount and Frequency of Rainfall for the Ten Years 1871 to 1880.

Hour.	Amount.					Frequency.				
	Dec. to Feb.	March to May.	June to August.	Sept. to Nov.	Year.	Dec. to Feb.	March to May.	June to August.	Sept. to Nov.	Year.
	in.	in.	in.	in.	in.					
Midnt.	·23	·15	·21	·24	·20	9·1	6·2	6·9	7·9	7·5
1	·23	·16	·22	·24	·20	9·2	6·9	7·8	8·2	8·0
2	·24	·17	·22	·23	·20	9·6	7·5	8·4	8·4	8·5
3	·24	·17	·22	·22	·20	10·4	7·9	8·7	8·8	9·0
4	·25	·16	·24	·22	·21	11·3	8·2	8·9	9·7	9·6
5	·24	·17	·25	·22	·21	11·7	8·5	9·0	10·0	9·8
6	·22	·17	·25	·21	·20	11·4	8·4	8·8	9·6	9·5
7	·23	·17	·23	·22	·20	10·9	7·9	8·2	9·3	9·0
8	·25	·16	·21	·24	·20	10·8	7·3	7·5	9·1	8·6
9	·26	·17	·20	·25	·21	10·6	6·8	6·8	8·8	8·2
10	·27	·16	·16	·24	·20	9·7	6·0	5·4	7·7	7·2
11	·27	·14	·13	·23	·18	8·3	4·8	4·1	6·3	5·9
Noon	·25	·13	·11	·22	·17	7·5	4·3	3·8	5·6	5·3
13	·25	·12	·11	·22	·17	7·5	4·5	4·1	5·7	5·5
14	·26	·13	·13	·22	·17	7·8	4·7	4·1	5·9	5·6
15	·24	·12	·15	·24	·18	8·1	4·7	4·1	6·0	5·7
16	·23	·12	·17	·23	·18	8·2	4·7	4·3	6·3	5·9
17	·22	·14	·20	·22	·19	8·2	4·7	4·7	6·7	6·1
18	·23	·14	·21	·23	·19	8·6	4·9	4·9	7·1	6·4
19	·24	·14	·20	·24	·19	9·0	5·3	5·1	7·4	6·7
20	·25	·14	·18	·24	·19	9·0	5·8	5·4	7·3	6·8
21	·24	·14	·18	·23	·19	8·7	5·9	5·7	7·2	6·9
22	·23	·14	·19	·24	·19	8·8	5·7	6·0	7·4	7·0
23	·22	·14	·20	·24	·19	8·9	5·7	6·3	7·6	7·2

The following are the total number of these entries for the 22 years, month by month :—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Snow .	19	12	23	5	2	0	0	0	0	2	5	24
Hail .	78	48	57	32	17	1	1	1	5	38	57	47

These figures show clearly that "hail" is probably always to be taken as "soft hail" or "graupel." Its extreme rarity in summer shows that it does not owe its origin to the same cause which produces the devastating hailstorms of the central European summer.

The figures for snow show maxima in March and December, of nearly equal value, followed by January and February. It is of course naturally to be expected that snow should fall pre-eminently in the winter, but the figures for hail are very remarkable. We have the principal maximum in January, with secondary maxima of equal value in March and November, while December and February do not fall far short of their adjacent months. On the whole 75 per cent of the entries of hail occur between November and March inclusive, and as we shall see below, they bear hardly any relation to the figures for thunder.

Thunder.

The entries under this head are all that are available; there is no record as to whether the thunder was near or distant, and lightning is comparatively seldom entered.

The monthly totals for 22 years are :—

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
15	11	7	4	4	7	7	12	11	12	14	7

The maximum is in January, with 15 instances in the 22 years. November comes next. There is a strongly marked minimum in April and May. The falling off of December to 7, between November (14) and January (15), is remarkable.

Fog.

In Mr. Scott's paper, "Fifteen Years' Fogs in the British Isles," published in *Quarterly Journal of the Royal Meteorological Society*, vol. xix., the statistics for a number of stations are given, and Valencia comes out very favourably among these. In the whole 15 years, only 81 fogs were reported there. The only stations with lower figures were Stornoway with 79, and Nairn with 77. The monthly figures for the three stations were as follows :—

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Valencia .	9	9	2	7	4	1	3	12	8	15	6	3	81
Stornoway	3	6	8	6	6	9	11	7	10	4	5	6	79
Nairn . .	6	1	5	7	6	16	7	8	14	2	3	2	77

The only remarkable feature about these figures is their extreme irregularity.

Sunshine.

The sunshine recorder was not erected until April 1880, so that the data do not cover so long an interval as those for the other elements. In the volume of *Hourly Means* for the year 1891, lately published by the Meteorological Office, we find a discussion of the sunshine records for the ten years, 1881-90, at the seven observatories, and from that volume the subjoined statements have been extracted. I shall deal exclusively with the figures representing the percentages of the greatest possible number of hours. (Table XVI. p. 287.)

The year commenced with a percentage of 21·9 in January, rising to a maximum of 43·3 in May. The figure then sinks to 31·7 in July, but rises to a second maximum of 35·9 in August; when this is past, the figures show a gradual decrease, until the minimum of 19·3 appears in December. (Fig. 4, p. 288.)

The mean annual amount is 33·8 per cent, corresponding to 1486·5 hours of sunshine. The largest figure was in 1887, with 40·3 per cent. The smallest percentage recorded is 29·2 in 1886, representing only 1286·8 hours out of a possible 4453.

In considering the individual months, we find that there is but little difference between April, May, and June, the respective numbers being 40·9, 43·3, and 39·9.

TABLE XVI.—MONTHLY AND ANNUAL TOTALS OF SUNSHINE, AND THE PERCENTAGE OF THE POSSIBLE AMOUNT FOR THE TEN YEARS 1881 TO 1890, WITH THE MEANS FOR THE WHOLE PERIOD, AND FOR EACH LUSTRUM.

Years.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Year.	
	hours	%	hours	%	hours	%	hours	%	hours	%	hours	%	hours	%	hours	%	hours	%	hours	%	hours	%	hours	%	hours	%
1881	125·45	48·8	69·75	25·2	123·9	33·8	161·9	39·0	282·7	58·5	157·25	31·6	120·4	24·2	129·6	28·8	123·25	32·7	89·2	27·2	64·5	24·5	62·1	25·8	1510·0	34·3
1882	40·95	15·9	48·55	17·5	119·65	32·6	170·55	41·1	260·0	53·8	196·15	39·5	150·05	30·1	173·05	38·5	141·75	37·6	121·0	36·9	68·0	25·9	58·35	24·2	1548·05	35·2
1883	37·9	14·7	50·4	18·2	176·7	48·1	197·2	47·5	232·15	48·1	219·55	44·2	133·05	26·7	141·05	31·3	112·95	30·0	86·1	26·3	57·75	22·0	36·75	15·2	1481·55	33·6
1884	20·45	8·0	63·55	22·1	93·85	25·6	158·45	38·2	191·65	39·7	185·9	37·4	155·0	31·1	139·1	30·9	125·15	33·2	99·75	30·4	75·65	28·8	31·25	13·0	1337·75	30·3
1885	49·85	19·4	60·95	22·0	134·1	36·5	163·65	39·4	200·6	41·5	220·85	44·4	165·35	33·2	205·35	45·6	116·75	31·0	94·7	28·9	42·8	16·3	41·45	17·2	1496·4	34·0
1886	53·75	20·9	61·25	22·1	88·85	24·2	130·55	31·5	164·75	34·1	176·8	35·6	159·3	32·0	114·45	25·4	110·15	29·2	103·6	31·6	65·35	24·8	58·0	24·1	1286·8	29·2
1887	50·95	19·8	91·0	32·9	167·2	45·6	256·85	61·9	188·0	38·9	293·6	59·1	193·05	38·8	166·85	37·1	164·7	43·7	90·95	27·7	70·15	26·7	43·1	17·9	1776·40	40·3
1888	71·15	27·7	97·9	34·1	156·85	42·7	140·35	33·8	238·7	49·4	173·1	34·8	156·3	31·4	191·6	42·6	157·45	41·8	94·65	28·9	44·4	16·9	53·4	22·2	1575·85	35·7
1889	57·15	22·2	81·55	29·4	140·8	38·4	153·05	36·9	168·2	34·8	241·4	48·6	213·9	43·0	139·75	31·1	87·4	23·2	121·85	37·2	41·5	15·8	35·3	14·6	1481·85	33·6
1890	55·3	21·5	110·3	39·8	124·55	33·9	166·6	40·1	163·8	33·9	119·45	24·0	134·45	27·0	213·5	47·4	83·3	22·1	80·9	24·7	71·65	27·2	44·6	18·5	1368·4	31·1
Means 1881–90	56·29	21·9	73·52	26·4	132·65	36·2	169·92	40·9	209·0	43·3	198·41	39·9	158·09	31·7	161·43	35·9	122·29	32·4	98·27	30·0	60·18	22·9	46·43	19·3	1486·5	33·8
Means 1881–85	54·92	21·4	58·64	21·0	129·64	35·3	170·35	41·0	233·42	48·5	195·94	39·4	144·77	29·1	157·63	35·0	123·97	32·7	98·15	29·9	61·75	23·5	45·98	19·1	1475·15	33·5
1886–90	57·66	22·4	88·40	31·7	135·65	37·0	169·48	40·8	184·69	38·2	200·87	40·4	171·40	34·4	165·23	36·7	120·60	32·0	98·39	30·0	58·61	22·3	46·88	19·5	1497·85	34·0

On four occasions during the ten years, the monthly total has exceeded one-half of the possible duration of sunshine. In 1887, 61·9 per cent was recorded in April, and 59·1 per cent in June. In May 1881 and 1882, 58·5 and 53·8 were the respective percentages. The amount has fallen below 20 per cent several times; in January five times,

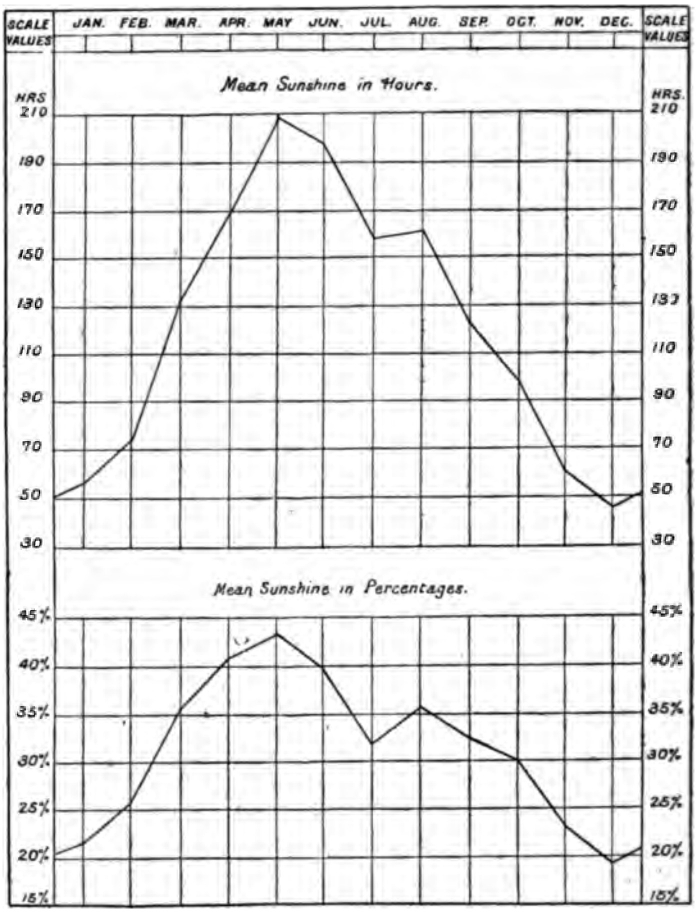


FIG. 4.

February twice, November thrice, and December six times. The blackest month of all was January 1884, with only 8 per cent.

The figures for the diurnal range of sunshine for the station will be found in the volume of *Hourly Means* already quoted, and the main facts of the phenomena have been given by Mr. R. H. Curtis in a paper on "The Hourly Variation of Sunshine at Seven Stations in the British Isles," *Quarterly Journal of the Royal Meteorological Society*, vol. xxi. p. 216.

DISCUSSION.

The President (Mr. E. Mawley) said that from a meteorological point of view, he did not suppose there was any other spot in the British Isles as interesting as Valencia Island, owing to its extreme westerly position. For it was from there that we received the first indications of approaching storms from the Atlantic. Any paper, therefore, giving in so complete a form as that of Mr. Cullum a record of its climate for twenty-three years could not be otherwise than valuable. Even twenty-three years was, however, too short a period from which to draw precise conclusions as to seasonal changes. Consequently, some of the curves the author had given would no doubt have come out smoother than they did had observations for a greater number of years been available. Then again, although the temperatures were undoubtedly extremely equable at Valencia, when we come to consider the position of the thermometers, the unusual size of the bulbs, and their height above the ground, they could scarcely be quite as equable as represented in the paper. That is to say, such temperatures could not be very well considered strictly comparable with those made elsewhere under less exceptional conditions as regards the exposure of the instruments.

Mr. B. Latham inquired whether the instruments were placed in a Stevenson screen, and whether there had been any comparison between the same and the photographic records.

Mr. R. H. Scott said that the thermograph thermometers were in a wall screen on the level of the first floor of the house, 12 feet above the ground. The great advantage of the records in the paper was that they were continuous, so that the extremes, especially of pressure, were not dependent on observations made at stated hours.

Mr. F. C. Bayard remarked that it would be interesting if a comparison were made between Valencia in the south-west, and Belmullet in the north-west of Ireland. As far as he could see, they were very similar in respect to temperature and rain. Was a published statement available?

Mr. R. H. Scott said that the mean results of temperature for the two stations, Valencia and Belmullet, from the telegraphic reports, would appear in the forthcoming appendices to the *Weekly Weather Reports* for 1895, while the daily reports appeared side by side every day in the *Daily Weather Reports.*

Mr. F. J. Brodie was surprised to find that while the description of instruments in use at Valencia included a brief reference to the anemometer, no attempt had been made to discuss the question of wind prevalence—a very important factor in regard to climate. A statement as to the relative prevalence of winds from different quarters would undoubtedly have been of great value, as also would information as to the average number of gales experienced at different times in the year. The interest of the paper would have been greater had some attempt been made to explain the causes of some of the more interesting features, and to point out the connection between the different meteorological elements. With respect, for example, to the extreme range of barometrical pressure in the various months, the author might have shown how the large range in January was due to the tendency not only for cyclones, but for anticyclones, to assume greater intensity in midwinter than in any other season. Similarly it might have been shown how the winter thunderstorms, so common at Valencia and on other parts of our western coasts, were due to the movements of the large Atlantic cyclones, the summer thunderstorms over England being occasioned, on the other hand, either by the advance of small, shallow systems, mostly from south or south-west, or by depressions which form directly over us. There was one point that seemed very difficult to explain,

and that was the strongly-marked barometrical minimum in April, a feature common to all places situated in the more southern parts of the united kingdom. In the northern districts the lowest mean pressures occurred, as a rule, either in January or November. The range in the annual rainfall was undoubtedly much smaller at Valencia than over England, the disparity between 69 inches in the wettest year, and 44 inches in the driest, being trifling as compared with London, where the records for the same twenty years showed amounts differing as widely as 32 inches and 17 inches. In spite of some defects and omissions the paper contained a large amount of very valuable information, and it was to be hoped that at some future time the records from the other observatories in connection with the Meteorological Council might be similarly dealt with. Additional information, say for Aberdeen and Kew, would complete a triangle, and afford interesting comparative results as to the weather in the western, northern, and south-eastern portions of the kingdom.

Mr. B. LATHAM inquired what measurement of rain constituted a rainy day.

Mr. H. S. WALLIS said that the rule printed in *British Rainfall* runs, "if the amount is under ·005 throw it away, if it is ·005 to ·010 enter it as ·01." The small difference at Valencia between the rainfall of the wettest and of the driest year struck him as remarkable. It is a sort of axiom for the British Isles that the wettest year will have roughly twice the fall of the driest, and an exhaustive paper read by Mr. A. R. Binnie before the Institution of Civil Engineers (*Proceedings Inst. C.E.*, vol. cix. session 1891-92) seemed to show that this rule applies to nearly all parts of the world.

Mr. T. W. BAKER thought that there was no doubt as to the value of the paper, but it was unfortunate that observations of the grass minimum thermometer were not included. The exposure of the anemometer at the former site of the observatory was scarcely so good as it was now, but it would be interesting, at some future date, to compare the curves recorded at the two stations.

Mr. R. H. SCOTT stated, in answer to Mr. Brodie, that a thoroughly satisfactory way of discussing anemometrical data had yet to be suggested. The method followed by Dr. Robinson in his discussion of the Armagh records, which had been more or less closely followed by the Meteorological Office in its discussions for Orkney, Bermuda, and Ascension, had not proved satisfactory in the variable winds of the temperate zone. Many important features were concealed by the resolution along four co-ordinates with *plus* and *minus* signs, by which system winds of equal velocity from opposite points cancelled each other. Professor A. von Oettingen had suggested the printing of the full four co-ordinates N.E.S.W. The winds at Valencia were very seriously affected by the hill rising to a height of 700 feet immediately to the north-west of the bay. The correction to the barometer for altitude was very small, as the cistern was only 23 feet above sea-level. With regard to Mr. Latham's question about the definition of a rainy day, Mr. Cullum had followed the practice usual in these islands of taking 0·005, or 0·01, inch as the limit.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 20, 1896.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

G. R. ANDREWS, C.E., F.R.G.S., Johannesburg, South Africa; and
HENRY AMBROSE HUNT, The Observatory, Sydney, New South Wales,
were balloted for and duly elected Fellows of the Society.

The following communication was read:—

"THE EXPOSURE OF ANEMOMETERS." By RICHARD H. CURTIS, F.R.Met.Soc. (p. 237).

A collection of 60 Photographs of Clouds, forwarded to the Society by Mr. H. C. RUSSELL, F.R.S., of Sydney Observatory, were also exhibited.

June 17, 1896.

Ordinary Meeting.

EDWARD MAWLEY, F.R.H.S., President, in the Chair.

ARTHUR LIDDALL BRIDGE, Stroud Green Road, Finsbury Park, N.;
HENRY EDWARD LEIGH CANNEY, M.D., M.R.C.S., Luxor, Egypt;
SEPTIMUS SUNDERLAND, M.D., 11 Cavendish Place, Cavendish Square, W.;
ARTHUR EDMUND THOMPSON, Leadenhall Buildings, E.C.; and
WILLIAM FERDINAND TYLER, LIEUT., R.N.R., c/o Commissioner of Customs, Shanghai,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

"ARCTIC HAIL AND THUNDERSTORMS." By HENRY HARRIES, F.R.Met.Soc. (p. 251).

"CLIMATOLOGY OF VALENCIA ISLAND, Co. KERRY." By J. E. CULLUM, F.R.Met.Soc. (p. 267).

CORRESPONDENCE AND NOTES.

Total Solar Eclipse, August 9, 1896.—The British Astronomical Eclipse party, under the presidency of Mr. E. A. Maunder, assisted by Dr. A. N. Downing, F.R.S., and others, arrived at Vadsö by the *Norse King* between 12 and 1 a.m. on Monday, August 3rd. The wind was light from the West, and although the time for seeing the midnight sun was past by a few days, the light at midnight was sufficiently good to enable photographs to be taken with

very slight exposure. Tested roughly by means of a photographic actinometer, the actinic power of the light at midnight was about one-twelfth of its mid-day value. The temperature in the open air was 61°·0, and the pressure 29·64 ins. at sea-level.

The instruments consisted of maximum, minimum, dry-bulb and wet-bulb thermometers in a Stevenson screen, a standard thermometer, a black bulb *in vacuo*, a terrestrial radiation thermometer, and two of Richard Frères' automatic instruments—a barograph and a thermograph—both capable of being adjusted so as to give an open trace of about an inch and a half to the hour. The wind direction and force was observed by a simple but effective instrument. A piece of cotton wool teased out was connected by means of a fine silk thread to the end of a fishing-rod. This responded to the slightest breath of air.

The screen was set up facing the north-north-west, on the signal post adjoining the lighthouse on the highest part of the island of Vadsö, opposite the town of that name on the north side of the Varanger Fjord, lat. 69° 51′ N., long. 29° 45′ E., height above sea-level 94 feet 7 inches as determined by an aneroid. The bulbs of the screen instruments were 3 feet 9 inches above short grass. The solar radiation thermometer was the same height above the ground a little to the south, while the terrestrial radiation thermometer was placed on short grass near it. The fishing-rod was attached to the upper part of the flag-staff above the screen, the cardinal points being marked on the ground. The barograph and thermograph were placed on the top of the Stevenson screen, protected by a board from the sun and rain.

Observations were taken at irregular intervals, the very defective arrangements for going to and fro—we lived on board ship—preventing the regularity desirable. Beside the observations taken at irregular intervals from the early morning of the 3rd until the evening of the 8th, at 9.30 p.m. on that day continuous hourly readings were made until 4 a.m. on the 9th, and then every *five minutes* until 6 a.m., when the hourly observations were resumed and continued until 12.30 p.m.

We left Vadsö on Monday, August 10th. The pressure at 95 feet above sea-level was 29·54 ins. on the 3rd at 1 a.m., and gradually and steadily rose each day, until at the time of the eclipse it stood perfectly steady at 30·07 ins.

The temperature made a rather sudden drop the day of our arrival from 61°·0 at 1 a.m. on the 3rd to 51°·0 at 5 p.m., and 48°·0 at 9.45 p.m. The highest shade temperature after this was 56°·9 at 5.30 p.m. on the 4th. The greatest difference between the dry and wet bulb was 4°·9 at 5.30 p.m. on the 4th. The solar radiation reached 123°·5 on the 6th, and the terrestrial radiation fell to 30°·3 on the 7th. During the eclipse the temperatures were:—At first contact, dry 45°·0, wet 43°·8 ; rose to 45°·3 and 44°·0 at 4.20 a.m. ; and fell to 44°·7 and 42°·9 at totality ; gradually rising to 45°·5 and 43°·2 at the final contact ; and at 12.30 p.m. to 50°·0 and 45°·8. The thermograph showed a sudden drop at the moment of totality of *two-tenths* of a degree and an evident agitation of the instrument.

The wind during the week of our stay was light, often falling calm altogether. Its maximum force was 2 (Beaufort scale) on several days. On the morning of the eclipse it was very light from the North, and during the first phase fell dead calm. At 6 a.m. there was still no wind, but by 9 a.m. it had risen to force 2 and backed a point to the West.

Mist was frequent, and several showers fell during the week, but the amount of the rainfall was comparatively small. On the night of the 8th rain fell from 8.55 to 9.15 ; and on the 9th from 12.32 to 1.25 a.m., and a few drops just at the moment totality began. The sky was overcast except a patch in the north-north-west, and as the cloud drift was from that point the sky would soon have cleared in the direction of the sun but for continual condensation taking place

over the higher land to our north and east. The sun was just once seen during the first phase for a moment, and throughout the whole time of its phases there were small spots on the hills to the south of the fjord, on which a beam of light rested. The clouds were very low and pretty dense, so that only a deep amber hue round the east and south sea horizons was discernible, together with the weird bluish colour of the clouds which made the spectacle of totality so very impressive.

The loss of light was not so great as had been expected. There was no difficulty in seeing objects round about. The seconds marked on a watch dial could distinctly be seen even through a celluloid covering. It certainly was much lighter than full moon.

On the 4th at 7.30 p.m. the moon was seen some three degrees above the hills to the *north.*—Rev. J. CAIRNS MITCHELL, B.D., F.R.A.S.

Whirlwind at Bridgwater.—On Tuesday afternoon, June 9th, the neighbourhood of Bridgwater, Somerset, was visited by a small cyclone or whirlwind. Mr. H. Corder, Sunnyside, Bridgwater, has sent us the following account, which has also appeared in the *Bridgwater Independent*:—

It would appear that at about 4 o'clock on the same day a small whirlwind was formed near Glastonbury, which carried up forty or fifty tiles from some cottages, and also conveyed a basket some distance through the air. It then seems to have gone up again to the clouds, but may have been the commencement of the one which visited us a little later. From what we can gather the whirlwind was formed not far from Dunwear, or between that place and Chedzoy, in the form of a long "tail" of black vapour hanging from the clouds, that it then moved towards Chedzoy, where it was met by an advancing storm cloud into which it seemed to merge, and then to turn back again towards the south, and immediately to lower itself among the tree-tops with a roaring noise. As the revolving wreaths of cloud drove through the trees they fell before it in rows, until in a few moments about forty trees were uprooted or snapped off in a space of about a quarter of a mile square. The centre of the cyclone seems to have passed down a ditch, where it has levelled the rushes and grass as if a torrent of water had rushed down the "rhine." Further on is a small orchard, and here all the larger trees are torn to pieces, and then the wind passed along a lane, leaving very distinct traces in the hedge where the brambles and grasses are flattened and tumbled about in a very curious manner. At the end of this lane is a cottage facing south, and the wind coming up behind it, or the sucking force exerted by the ascending whirl, blew out most of the windows into the garden, but fortunately did not unroof the house. From here the storm must have pretty nearly followed the course of the lane from East Bower to Dunwear, as several trees are broken and uprooted as far as Mr. May's farm. At the Great Western station the newspapers were scattered all over the platform, the carriage works had a narrow escape from being unroofed, and some amount of damage was done. Passing over the low ground the whirlwind next touched the trees round Mr. F. J. Thomson's grounds at Hamp, some apple trees were uprooted, and an elm snapped off at some height from the ground, and many smaller boughs broken in the plantations near, and in an oak tree a large limb was wrenched off and flung over among the other boughs. The writer was at this moment, 4.25 p.m., standing at the end of Northfield, where the crashing of the falling trees could be distinctly heard, and the whirling clouds and wind waving the distant trees had a very strange and awe-inspiring appearance.

In the lower part of the town the clouds seemed almost to touch the roofs, and the drifting masses of dark vapour were thought by many to be caused by a great fire near by. No doubt the phenomenon appeared under very different

aspects for different stations, but from Northfield the sequence of events was in some such order as this:—At first a heavy thunderstorm passed from east to west, apparently between us and Petherton, and in its rear another rapidly formed in the east and north-east. This then divided, part going towards the north, the other towards the south, while the whirlwind passed between them, the higher mountainous clouds moving very slowly and towering high into the air, whilst below torn shreds of vapour were being whirled from all points of the compass, the centre of the storm especially being most marked, the clouds seemed to be rolled up and drawn into the intense black thundercloud in the south, while in a few moments it cleared as if by magic in the north and east, as the rushing wind swept over the neighbouring trees. Both sections of the storm then seemed to join again, apparently over Combwich, and loud peals of thunder and bursting reports like cannon pealed out from the solid black mass, which entirely hid the distant hills, with the torrents of rain falling over Cannington and neighbourhood. One of the strangest parts of the phenomenon was the unearthly humming sound caused by the whirlwind after it had again risen into the thundercloud, and which was plainly audible from the low fields for a considerable time in the distance.

The rainfall here was under half-an-inch for the whole 24 hours, and none fell during the whirlwind or immediately after, and at present no accurate record has been sent us as to the amount which fell where the storm passed subsequently.

Whirlwind on the Thames.—On Sunday afternoon, September 20th, the cutter yacht *Cyclone*, 8 tons, Board of Trade register, was beating up the Horse Channel against a strong ebb tide and a moderate Westerly breeze. The sea was slight, as is usual when wind and tide are in the same direction; the glass had been steady all day at 29·75 ins. At (I think) about 3.30 p.m. a squall was seen slowly approaching from the Isle of Sheppey, and we lowered the jib-headed topsail. At the same time a rainbow astern showed that a rain squall, which had missed us, was passing away to the eastward. The coming squall showed three flashes of lightning, the most vivid of which was horizontal, and its great apparent length—about four points of the compass—seemed to indicate that the discharge was close to us. On the other hand, the thunder was not loud, and was not nearly simultaneous with the flashes—from which fact, and from what followed, I am inclined to think that the electrical storm was some distance in the rear of the rain squall. The latter proved to contain more rain than wind, and, though evidently of great width, north and south, was of little depth. From the first drops of rain to the last was not more than three minutes. So far nothing extraordinary had occurred. The rain stopped, the sky cleared, and we again ran up our topsail.

Ten minutes or a quarter of an hour afterwards I was taking off my oilskins on deck and remarking the peculiar appearance of the departing squall, which looked like a row of webs suspended from sky to sea, when an exclamation from the helmsman called my attention to a new and very terrible danger. In two minutes we had every stitch of sail off the boat, although, being in a narrow channel, we were in imminent risk of drifting aground, and had leisure to observe the phenomenon with comparative equanimity. We were off Reculvers; the time was about 4 p.m. On our port bow was a circle (ten or twenty feet in diameter) of boiling steaming water, travelling down with the wind, though apparently in no very straight line, and revolving rapidly the while in "the way of the sun" upon its own centre. Perhaps the best idea I can give of it is by asking you to imagine a cauldron of the diameter mentioned immersed to the brim and full of water in violent ebullition, the water leaping up in places and covered with spray and spoondrift, which in the upper layers were so finely divided as to look like steam, the whole whirling round with extraordinary

rapidity. There was no appearance of a waterspout—perhaps because it was not raining at the time—and the "steam" did not rise more than two or three feet above the surface of the surrounding (normal) waves. The phenomenon, that is to say the *effect* of the whirlwind, was visible only on the surface of the water. I cannot describe the weirdness and *wickedness* of its appearance, an effect principally due to the impression which it produced upon the mind that it was a living, sentient, and evil thing. A paid hand on board compared it to "a nest of white serpents twirling and twisting and gambolling," and spoke of the apparition as *he*. He said that in fifteen years' experience off the east coast as fisherman and yacht hand, he had never seen anything like *him*. *He* passed us at a distance of about 200 yards in about 2 fathoms of water. We saw *him* pass two other yachts and a barge about half a mile astern, which, like us, had lowered all sail upon *his* approach. *He* seemed to be making straight for an excursion steamer which was coming through the Horse Channel, and we expected to see the air filled with hats and parasols and "presents from Margate," but *he* passed astern of the steamer and we saw *him* no more, being too busily occupied in getting up sail to watch *him* further. The sky was dull (white), but the light was good, and the clouds (white) apparently high, but a quarter of an hour or so after the *thing* had passed there was a flash of lightning and a peal of thunder so simultaneous and startling that I instinctively glanced at the masthead, and, indeed, I think the discharge must have passed through the shrouds (steel) into the sea, which at the time was washing over the lee rail. I may add that at five o'clock we saw two mock suns, and that for half an hour or so after the moon rose the reflection of frequent flashes of lightning was visible between her and the horizon.

I could not get a reading of the barometer during the passing of the whirlwind and of the rain-squall which preceded it, but two readings at half an hour interval in which the phenomena occurred gave the same result, namely 29·75 ins., so that if the mercury was affected at all it must have recovered itself very quickly. From the force of the whirlwind and its small diameter I am of opinion that it would in a moment have disabled any sailing vessel which it caught unprepared.—H. HALL, 23 Cedars' Road, Beckenham, Kent.

Rainbow at Cape Town, June 6, 1896.—I am writing to tell you of a rainbow which I saw here, which, in my experience, is unique, in the hope that it may be of some interest. I should say that my notes were made within half an hour of my seeing the bow, so that they are so far trustworthy.

Cape Town, 5 p.m. (local time), June 6th.—I saw a double rainbow in the fog in front of Table Mountain, extending over the bay. Its arc was about 120°. The primary bow (red outside) was bright, and inside it I counted four other reds concentric with the first; the other colours were too faint to be seen. The secondary bow (outside the first, red to inside of bow) was fairly distinct all through the arc of the primary bow, and outside it again a second red was distinctly visible. The distance between the successive reds in the primary bow diminished as you passed towards the centre. The bow was fairly permanent. I watched it for over five minutes myself, and I do not know how much longer it may have lasted. I have never seen such a perfect specimen, and do not know if it is of specially rare occurrence.—R. J. S. SIMPSON.

Remarkable Electrical Phenomenon.—In the *Zeitschrift für Elektrotechnik* a description is given of the following unique display of atmospheric electricity which was observed by a farmer while driving along a narrow private road having a wire fence on each side. When his vehicle had gone about 400 feet from the commencement of the wire fences his attention was attracted by a bright light behind him. On looking round he saw fire balls about the size of a man's hand travelling towards him along the wire on both sides. In a moment they

[illegible] moved along with it *pari passu*, while [illegible] from a large electric machine, were [illegible] apparently, the iron parts of the [illegible] distinctly heard, and a torrent of [illegible] and horses. The frightened [illegible] of their fiery escort till the [illegible] or noise, other [illegible] was heard. The whole phenomenon [illegible] the next day to see whether [illegible] the carriage by some [illegible] would justify such an [illegible] as if by heat, and every- [illegible] phenomenon. The time [illegible] thunderstorms in the neigh- [illegible]

[illegible] twenty-nine towns is [illegible] Heft vii. [illegible] recorder, [illegible] years, while a [illegible] amounts [illegible] the full year of

[illegible] of sunshine [illegible] The stations [illegible] —Emden, 1770 [illegible] 1773; Ditschau, [illegible] Baltic coast, in a [illegible] hand, there [illegible] Isles seem to [illegible] Baltic Seas, for [illegible] Hamburg, [illegible] Bremen have [illegible] the stations [illegible] of England, [illegible] receive less [illegible] 1614; Magde- [illegible] notable excep- [illegible] south, independent [illegible] Padua, and Rome [illegible] these be added the [illegible] will be seen that the [illegible] towards the south than

[illegible] the duration of sun- [illegible] mountains. On the other [illegible] heights and their cloud- [illegible] Thus the Inselberg, [illegible] 13[illegible]0 feet lower, has [illegible] summer and autumn. Again, [illegible] respectively, as against [illegible] being 34, 37, and 41

[illegible] The hours of sun- [illegible] maximum, and as gradually

decrease. The position of the minimum is remarkably constant. Except at Ellewiek and Poppelsdorf, where it occurs in January, the minimum always appears in December—that is, on the shortest days, when, the sun being low, the rays have to penetrate a thicker stratum of air. The absolute amount varies in general from 30 to 40 hours, or 13 to 17 per cent. It is still less at Marggrabowa, Kiel, and Eberswalde (10 per cent), Hamburg (9 per cent), and Stuttgart (3 per cent), while it is above these limits at Leobschütz, Erfurt, and Emden (20), Chemnitz (21), Jena (22), Ellewiek and Poppelsdorf (22 to 23). The maximum has a less uniform character. It does not fall in the period of the longest days, for almost everywhere, at least in Northern Europe, there is a falling off in the duration of sunshine in June and July. Over the whole of North-western Europe there is a pronounced maximum in May, generally followed by a secondary maximum in August. As the latitude becomes lower, and the longitude increases, the chief maximum moves more and more toward the summer, until at last the positions of the two maxima are reversed. South France, Switzerland, the Adriatic, and whole of Southern Europe have the chief maximum in July or August. At the German stations the August maximum averages something under 50 per cent, and in a few cases reaches 52. In the south much higher values are attained: Vienna, 54 ; Zürich, 57 ; Trieste, 66 ; Montpellier, 67 ; Lugano, 67; Rome, 75 ; and Madrid, 84. On the mountains the duration of sunshine is more equally distributed throughout the year. On the Sonnblick the monthly minimum is 115 hours, while the maximum is 151; and on the Obir and Säntis the range is much the same. Again, the winter months are very sunny, the percental maxima occurring at this season.

The daily period is also very simple in its variation. On the whole, the duration of sunshine follows the course of the sun, rising in the morning to a maximum in the middle of the day, and then declining. Little sunshine is registered in the early morning and late in the evening, owing to the low altitude of the sun, but, as a rule, twice as much is registered towards sunset as near sunrise. The increase is much more gradual than the decline, which is very marked from 4 p.m. At high stations the variations follow in reversed order. Sunshine is most frequent and of longest duration between one and two o'clock at most stations, but at Rome and Madrid the maximum is reached between ten and eleven o'clock, and at high-level stations an hour earlier. At the beginning of the year the daily maximum is usually at mid-day, and is reached at an earlier hour as the summer approaches, returning to its former position at the end of the year. At the German coast stations, however, the maximum has a tendency to move to the hours of the afternoon. One peculiarity in the daily variations is, that in the warmer season there is often a depression in the curve of sunshine at mid-day, so that the maximum is separated into two parts by an intervening minimum. The cause probably lies in the formation of clouds, which, as shown by hourly observations at Görlitz and Potsdam, is greater between eleven and two o'clock than earlier or later.—*Scottish Geographical Magazine*, October 1896.

Mont Blanc Observatory.—With respect to the results obtained by M. Janssen at his observatory on the summit of Mont Blanc, Mr. T. H. Morgan sends us the following particulars:—

1. The vexed question of whether the traces of oxygen observed in the solar spectroscope were due to the sun's light or to our own atmosphere has been settled. The evidence of oxygen (as we chemically know it) is entirely absent; a main question to settle.

2. The diurnal barometrical variation, which is scarcely marked at or near sea-level, is of a very pronounced character.

3. The diurnal temperature range is very small relatively to that of the

Grands Mulets, Chamounix, etc., and still relatively smaller to that at Geneva and on the plains.

4. The hygrometric state is very much opposed to the curves observed below, *e.g.* at the time at Geneva and Chamounix when the air gets driest (at or towards mid-day) the air at the summit begins to get moister, this moisture culminating at 6 p.m. in summer.

5. The temperature of the glacier decreases from the near surface.

6. The size of the grains of ice increases in depth, not because the water is dissolved from the surface and descends to thicken them, as was thought by most, but simply by pressure; for it is observed on the summit glacier where no water is ever produced by the sun's heat.

7. In violent storms the wind does not, as might have been imagined, blow with steady pressure, due to no interruptions of surface configuration, as at points below, but has rapid alterations of pressure. An instantaneous downward movement to nearly a tenth of an inch precedes a very violent gust, which latter follows immediately. The barometer then rises, and a period of relative calm comes on, till in a minute or two there is a repetition of the same thing. Hence it follows that the gusty state of storms at the earth's surface is not due to configuration, but to general high atmospheric whirlwind conditions. This statement is open to a query.

New England Meteorological Society.—We regret to learn that this Society has been dissolved. The reason for this action is stated by the Secretary to be as follows:—"Since the system of meteorological observations in New England, and the publication of a monthly bulletin were transferred to the New England Weather Service several years ago, the chief service of the Society, apart from its meetings, has been in the assistance it gave to the *American Meteorological Journal*, by subscribing for it for all regular members. Now that the *Journal* is to be discontinued by reason of insufficient support, the meetings of the Society, attended only by few of its small number of members, seem a hardly sufficient object to warrant the continuance of the organisation. The Council therefore voted to recommend that the Society be dissolved at the end of the present Society year."

RECENT PUBLICATIONS.

American Meteorological Journal, Vol. XII. No. 12. April 1896. 8vo.

The principal articles are:—A speculation in topographical climatology: by Prof. W. M. Davis (10 pp.).—The new meteorological observatory on the Brocken: by A. L. Rotch (3 pp.).

We regret that this interesting and useful publication ceases with this part. The editor gives the following reasons for its suspension:—"It is probably known to our readers of the *Journal* that its publication has been attended with a very considerable financial loss on the part of the editors ever since its foundation in 1884. The *Journal* could never have been started and maintained through the early years of its life without the very generous financial aid given it by Prof. Mark W. Harrington and Mr. A. Lawrence Rotch, and during the last few years it has only been continued at a further yearly loss on the part of the editor. This is equivalent to saying that the *Journal* has not received the support from the country at large that it seems to the proprietors and editors to have deserved. As long as there seemed any prospect of obtaining this support, the voluntary financial assistance thus freely given it was gladly contributed.

After a trial of twelve years, however, without any marked increase in the subscription list, those who have been most zealous in assisting the *Journal* feel discouraged at the outlook, and see no other solution of the problem than a complete suspension of publication. In justice to the publishers, Messrs. Ginn and Co., of Boston, it should be stated that the decision to suspend publication was reached by the proprietors alone, and was not in any way brought about by a desire to discontinue on the part of the publishers, even though the *Journal* has every year caused them a pecuniary loss."

British Rainfall, 1895. Compiled by G. J. Symons, F.R.S., and H. Sowerby Wallis. 8vo. 1896.

In addition to the usual rainfall data from 3084 stations distributed over Great Britain and Ireland, this contains several articles upon rainfall work. The principal article is that entitled "Seathwaite's Jubilee, 1845-94." Seathwaite, which is situated in Borrowdale, Cumberland, is about a mile north of The Stye (the reputed wettest spot in the British Isles); and it is interesting to know that continuous rainfall records exist for this place extending over half a century. The results show that the average yearly rainfall is 135 ins.; the wettest year having 182 ins. and the driest year 88 ins. The greatest monthly rainfall was 35·41 ins. in November 1861, and the least monthly rainfall 0·59 ins. in September 1894. There are nine recorded cases of more than 6 ins. falling in one day—probably there have been about a dozen; the heaviest recorded was 7·52 ins. on November 26, 1861.

Meteorologische Zeitschrift. Redigirt von Dr. J. Hann und Dr. G. Hellmann. May—September 1896. 4to.

The principal articles are:—Ueber holosphärische Isanomalen der Temperatur: von E. Sella (6 pp.). Dove in his isabnormal maps took the theoretical temperature for each parallel in the two hemispheres separately and referred the actual temperatures to the figures so obtained. M. Sella takes as the real temperature of each parallel the mean of the theoretical temperature for the corresponding parallels in both hemispheres, and consequently obtains a series of lines which differ more or less from Dove.—Tägliche Periode der Luftströmung in Bezug auf Richtung, Geschwindigkeit und Drehung: von J. Hegyfoky (10 pp.). This is a discussion of the diurnal shift of wind and cloud at Tur Kevi, in the central plain of Hungary, carried out from March to September inclusive, in the years 1894 and 1895. Two hourly observations were made from 5 a.m. to 9 p.m., but the only instruments available were a Wild's pressure plate and a wire ring as a nephoscope. The general result of the discussion is that the wind has a tendency to shift towards the direction from which the lower clouds are moving. In the region of the clouds the tendency is to shift against the general Westerly wind.—Experimentelle Untersuchung des Assmann'schen Psychrometers: von A. Svensson (13 pp.). This paper is not complete, as the mildness of last winter prevented the obtaining of data during severe frost. The paper deserves careful study from persons interested in the theory of the wet-bulb hygrometer.—Atmosphärische Elecktricität: von Prof. A. Schuster, (15 pp.). This is a translation of a lecture delivered at the Royal Institution, London.—Obere Luftströmungen über der indischen Monsun-Region: von W. L. Dallas (6 pp.). This is a continuation of a paper Mr. Dallas sent to the Royal Meteorological Society in 1893 (*Quarterly Journal*, vol. xix. p. 239), which dealt with the movements of the upper currents over the Arabian Sea. The present paper deals with the Bay of Bengal, and unfortunately the Arabian Sea is not included, as the original numbers on which the Arabian Sea paper was based

have been lost. The chief fact which comes out is that the cirrus changes its direction with the Monsoons:—December to February is N. 19° E.; March to May, S. 50° W.; June to August, S. 11° W.; and September to November, N. 45° E. The movements are shown on four charts. Mr. Dallas at the close points out that he has found it impossible to connect the cloud motion at the level of 10,000 feet with the pressure distribution below. The great difficulty in this is that clouds almost always arise from disturbances of the atmosphere, and of this he gives instances. Another difficulty is that observers do not estimate cloud elevation correctly or uniformly. In the South-west Monsoon three distinct strata of air motion exist. The lowest is from South-west; above this comes a motion from South-east and East; and above all there is the return current from the thermal equator to the southern hemisphere. Observers become confused between these three currents.—Ueber Anemometer-Aufstellung: von R. H. Curtis (7 pp.). This is an abstract of Mr. Curtis's appearing in the present number of the *Quarterly Journal*, p. 237. The Council allowed an advance proof of the paper to be sent to Vienna for publication in the *Zeitschrift* in view of the approaching International Meteorological Conference in Paris.—Ueber die Beziehungen zwischen hydrographischen und meteorologischen Phänomenen: von A. Pettersson (36 pp.). This is an account of the work which the author, with Dr. G. Ekman, has carried out during the last five years, in correlating the surface temperature and saline contents of the sea water in the North Sea and Baltic with the weather of Scandinavia. In this country Mr. H. N. Dickson has joined in the work, and has made various trips in the *Jackal*. Dr. Pettersson is of opinion that a systematic record of the sea temperature would give great assistance in forming a judgment as to the coming weather, *i.e.* the general character of coming seasons. The paper concludes with an account of the organisation in Sweden and the adjacent countries for the coming winter, and an appeal for co-operation from other countries, and from Atlantic steam lines.—Psychrometrische Studien und Beiträge: von O. Edelmann (23 pp.). This is an elaborate investigation into the whole question of Hygrometry, which requires most careful study. The author concludes by saying that Assmann's instrument is the best of its kind, and that for the dry and wet bulb thermometer Auguste's formula is the best, but that this form of hygrometer can never give satisfactory results at low temperatures, and no general formula can be accepted.

Proceedings of the Royal Society. Vol. LIX.-LX. Nos. 358-359. 1896. 8vo.

Contains:—Report of the Kew Observatory Committee for the year ending December 31, 1895 (32 pp.).—Observations on atmospheric electricity at the Kew Observatory: by C. Chree, Sc.D. (37 pp.). The author finds that there is a connection between low potential and long previous sunshine, high temperature, low barometric pressure, and high wind velocity. It is also probable that the potential tends to be higher during anticyclonic than during cyclonic weather.

Proceedings of the Royal Society of Edinburgh. Vol. XX. 1895. 8vo.

Contains:—On some observations made without a Dust Counter on the hazing effect of atmospheric dust: by John Aitken, F.R.S. (16 pp.). The conclusions arrived at in this paper may be summed up as follows:—Accepting the two following conclusions arrived at in previous communications on atmospheric dust, namely, that when the wind blows from populated areas the number of dust particles is always very great, and that for a given humidity the thickness of a haze is in proportion to the number of dust particles present, observations were made to test to what extent the air from populated areas was

hazed compared with that blowing over thinly populated districts. Falkirk is so situated that the winds from the West, North-west, and North come to it but little polluted, whilst from all other directions it comes polluted by its passage over more or less densely populated districts. By comparing the haze on days when the air had the same humidity, the relative transparency of winds from different directions has been obtained—that is, the relative transparencies of the air from polluted and from unpolluted areas. Winds from the West, North-west, and North are more than six times clearer than the Southerly winds when the air is damp, and more than nine times clearer when the air is dry enough to give 3° or more of wet bulb depression. The air near Falkirk is about ten times more hazed when the wind is East, South-east, South, and South-west than it would be if there were no inhabitants in the country. The transparency of the air increases with its dryness, becoming about 3·7 times clearer when the wet-bulb depression is 8° than when it is 2°. That is, the clearness of the air is inversely proportional to its relative humidity ; or, put another way, if the air is four times drier, it is about four times clearer. The isatmid lines for Falkirk for the different directions of wind at different humidities show that the density of the haze in our atmosphere is proportional to the density of the population in the direction from which the wind blows ; the isatmid lines for all humidities being closer to the place of observation, the denser the population in the direction from which the wind blows.

Symons's Monthly Meteorological Magazine. July—September 1896. 8vo.

The principal articles are :—The International Cloud Atlas (2 pp.).—The worst gale of the nineteenth century in the English Midlands : by J. G. Wood (2 pp.).—The spring drought of 1896 (6 pp.).—The Thames run dry (3 pp.). The years in which it was possible to walk across the Thames at London Bridge were as follows : 1114, 1158, 1281, 1541, 1591, 1592, 1687, and 1716.—The first use of kites in Meteorology : by A. L. Rotch (2 pp.).—The first Daily Weather Map, sold in the Great Exhibition of 1851 (1 p.). A reduced copy of this map is attached to this article.—Whirlwinds at Bridgwater and Eastbourne (3 pp.).

INDEX

THE END

Printed by R. & R. CLARK, LIMITED, *Edinburgh*

MEZZANINE